BUILDERS' MACHINERY AND EQUIPMENT

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NEWNES' BUILDING PRACTICE SERIES • VOLUME 3

BUILDERS' MACHINERY AND EQUIPMENT

DEALING WITH LIFTING EQUIPMENT, STEEL SCAFFOLDING, SMALL TOOLS, CONCRETE MIXERS, EXCAVATING MACHINERY, AND TEMPORARY TIMBERING

Prepared by a Staff of Technical Experts under the direction of

E. MOLLOY

WITH ONE HUNDRED AND FIFTY-SIX ILLUSTRATIONS

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PREFACE

CONSIDERABLE development has taken place in recent years in builders' plant and equipment. Such mechanical aids to builders' work as lifting appliances, portable tools, concrete mixers, and excavating machinery, are taking the place of old-established hand methods more or less rapidly. The builder who does not avail himself of modern appliances is seriously handicapped in competition with more modernly equipped rivals. The building operative also is handicapped if he does not know how to use this modern equipment. On the other hand, the labour-saving tools introduced into the building trade can be a serious disappointment unless care is taken in buying and using. When dealing with the subject in the present work, therefore, the object in all cases is to review the equipment available, to give practical advice on the use of the equipment, and to point out the likely troubles that will be met with in practice, and the best methods to adopt to keep down repair costs.

Lifting equipment, both power and hand appliances, are dealt with in Chapter II ; portable tools in Chapter IV ; concrete mixers in Chapter V ; and excavating machinery in Chapter IX.

An item of equipment which has many advantages for its purpose is steel scaffolding, dealt with in Chapter III. This type of scaffolding is more rapidly erected than the pole scaffold ; it is less likely to deteriorate, it is more convenient, and it takes up far less space when stored. Here again, however, care is necessary in its use and maintenance.

All these chapters are written by users of the equipment dealt with, and are the fruit of practical experience.

Apart from the above are the chapters devoted to the important item of builders' equipment—the various types of temporary timbering required for builders' work. Under this heading are included all timber work necessary for shoring up walls, floors, and roofs of buildings (Chapter I) ; formwork for erecting concrete structures, in which concrete is cast until it sets (Chapter VI) ; timber for centres for arches (Chapter VII) ; and timbering for supporting the sides of trenches (Chapter VIII).

It is felt that the chapter on shores and shoring will be of particular value to builders at the present time, owing to the number of buildings damaged by enemy action where need has arisen for temporary support until repair or demolition can be effected. All the essentials are given in this chapter to enable an effective shore to be erected for whatever purpose it is required.

A. J. C.
E. M.

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BUILDERS' MACHINERY AND EQUIPMENT

Chapter I

SHORES AND SHORING

WHEN extensive alterations or repairs are necessary, a building may have to be temporarily supported by means of " shores." The three types usually employed are termed " dead shores," " flying shores," and " raking shores." A " dead shore " actually supports the " dead weight " of the wall. A " flying shore " is horizontal and incapable of taking any vertical load, its function being to keep the wall plumb. A " raking shore " is something between the two. It supports the wall to a certain extent, and also imposes a horizontal thrust to keep it upright.

Stability of Walls

A wall is stable so long as its centre of gravity falls inside the " middle third " of its base. Fig. 1 shows a wall leaning slightly but still stable. It may not require " shoring up " to prevent its falling, but it does require support to prevent it going farther off the plumb. Suppose that further subsidence of the foundation takes place, and, being a boundary wall, it is exposed to the force of the wind ; a certain amount of force would be thrown against the " shore." If the " shore " consisted of a single " raker " set at an angle of 45°, it would press vertically and horizontally an equal amount. If the combined weight of the leaning wall and the wind-pressure amounted to, say, 1,000 lb., then the weight of the material above the wall piece must be at least 500 lb. ; otherwise it would be lifted, and collapse would follow.

Types of Shores

Diagrams of shores are shown in Fig. 2.

Dead Shore

In the case of the " dead shore," buckling might be said to be the principal danger ; therefore the thickness of the support must be in proportion to the length, to give the necessary stiffness. The support will buckle on the thinnest way of the timber, so " die-square " timbers are best. A 6-in. by 6-in. " dead shore " would stand up to its load better than a 12-in. by 3-in. although their respective cross-areas are the same. The latter would be liable to buckle on its 3-in. side.

Flying Shore

In " flying shores," " wracking " might be termed the danger to be guarded against. A triangle cannot change in shape if the three sides

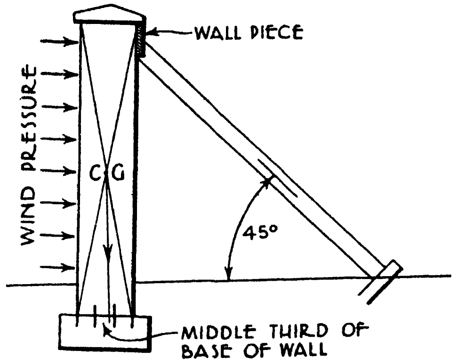


Fig. 1.—A RAKING SHORE

A wall is stable so long as its centre of gravity falls inside the "middle third" of its base.

remain unaltered in length. The triangle ABC, Fig. 2, is made up of part of the horizontal member AC, half the wall piece BC, and the brace AB. The "needle" at B prevents the point of the brace from moving upwards, the straining-piece keeps A in position, and the distance BC is constant between the mortices in the wall piece. If the joints are properly constructed, the triangle ABC, and the other triangles making up the whole "shore," remain unaltered in shape, therefore "wracking" is avoided.

Raking Shore

In dealing with the example shown in Fig. 1 it was stated that the "raking shore" pressed vertically and horizontally an equal amount. The thrust along the line of the "raker" is split up into vertical and horizontal components. Therefore it follows that to support a vertical load a "raking shore" is less effective than a "dead shore." Neither would it be as good as a "flying shore" to counteract horizontal pressure, but it is the type of shore used for walls fronting on a street. A solid bearing at D, to guard against subsidence (as suggested in Fig. 2 at D), and joints properly fitted are essential.

Load on Dead Shores

Before calculating the size of the "needle" necessary to carry the weight of the portion of the wall shown in Fig. 3, it would be advisable to study Fig. 4. A piece of yellow deal 1 in. by 1 in., laid on supports 1 ft. apart, will break when a weight of about 4 cwt. is placed at the centre. Take now a piece of 1 in. by 2 in. (*b*); being double the breadth it will carry double the load, viz. 8 cwt. So "the load varies directly as the breadth." Turn the piece of 1 in. by 2 in. on edge, as at (*c*), and it will take a load of 16 cwt. to break it. Compare (*c*) with (*a*): the depth is doubled but the load is squared: $4 \times 4 = 16$ cwt. So "the load increases directly as the square of the depth." Refer to (*d*): where the span is doubled it will take only 2 cwt. to break it. So "the load varies inversely as the span." At (*e*) the 2 ft. span is retained, but the piece is increased to 2 in. by 1 in. on edge. Work this out by the formula $BW = \frac{Cbd^2}{L}$, where BW stands for breaking-weight in cwt., C = constant, b = breadth of beam in inches, d = depth of beam in inches, L = length of span in

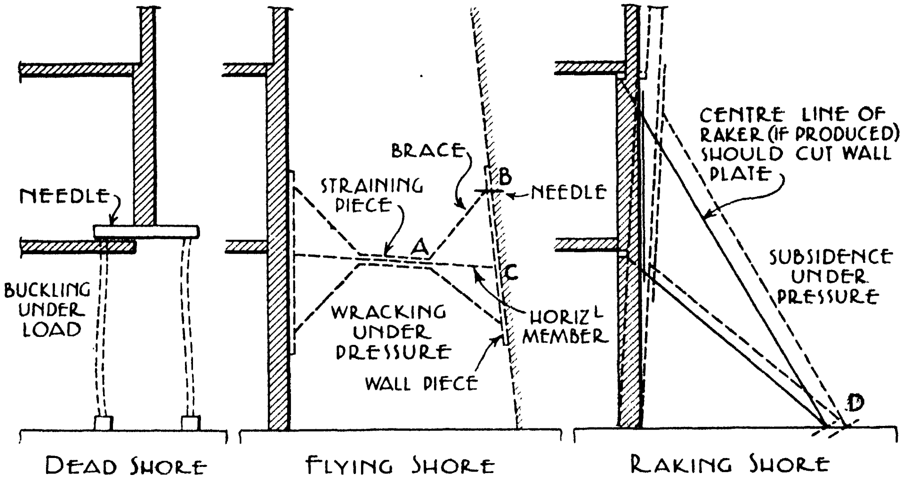


Fig. 2.—THREE EXAMPLES OF SHORES

A dead shore actually supports the dead weight of the wall ; a flying shore is horizontal and incapable of taking any vertical load ; and a raking shore is something between the two.

feet. BW $= \frac{4 \times 1 \times 4}{2} = 8$ cwt., so the " beam " at (*e*) will break under a load of 8 cwt.

Simple Experiment

To appreciate this, take a piece of yellow deal 1 in. by 1 in. and lay it on bricks 2 ft. apart. It should take a man of 16 stone to break it when he puts his weight at the centre. This would not be an accurate test from a theoretical point of view because the load is not concentrated on a " point " at the centre, but in practice similar conditions occur. In the example shown in Fig. 3 the load is distributed over the thickness of the wall. Timber, being one of Nature's products, may vary with every specimen tested, but 4 cwt. is found to be the average weight under which a sound specimen of yellow deal will break when tested as shown at (*a*) Fig. 4. This 4 is then called a " constant," C in the formula. For Douglas fir and pitch-pine this " constant " might be 4·5 or 5, on account of their greater transverse strength.

Factor of Safety

As stated, specimens of the same kind of timber vary, so to allow for this " a factor of safety " is adopted. If an actual load of 140 cwt. has to be carried, this load is multiplied by 4 (factor of safety), and the beam is assumed to be carrying $140 \times 4 = 560$ cwt.

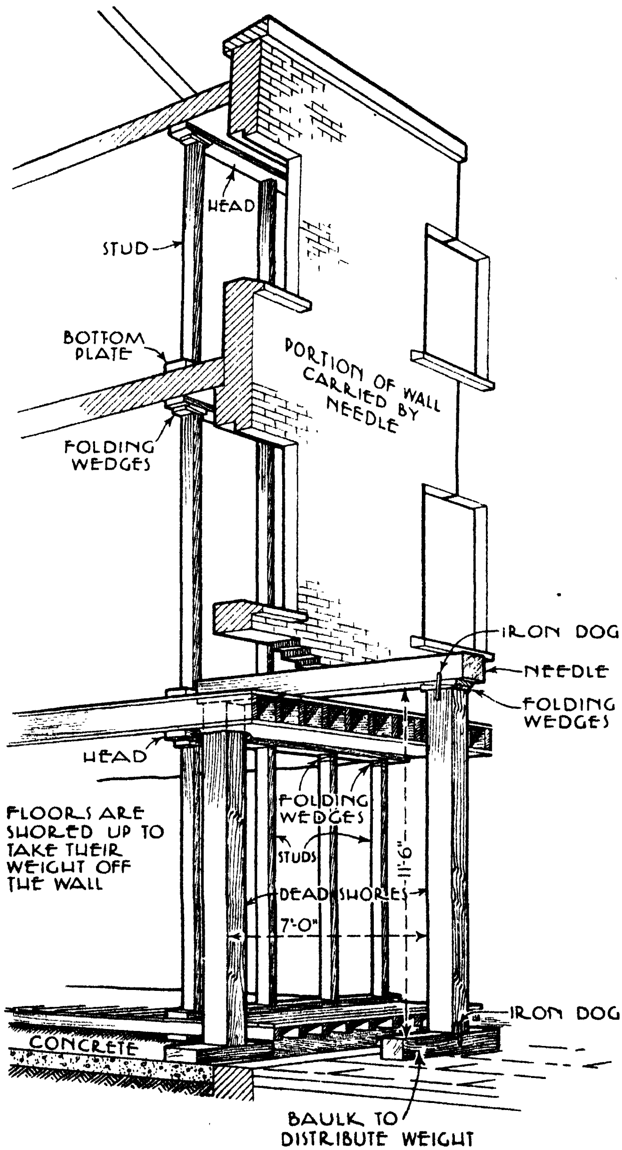


Fig. 3.—A DEAD SHORE

Showing load distributed over the thickness of the wall.

Calculation for Size of Needle

The "needle" in Fig. 3 carries a load of approximately 140 cwt. The "needle" is subjected to this load at the centre of the 7-ft. span. But the "needle" must be strong enough to carry four times this load, viz. 140 × 4 (factor of safety) = 560 cwt. Now BW $= \frac{Cbd^2}{L}$. Try how a 9-in. by 9-in. "needle" will stand the load:

$$BW = \frac{4 \times 9 \times 81}{7}$$
$$= 416{\cdot}6 \text{ cwt.}$$

This is on the small side. Try 10 in. by 10 in.:

$$BW = \frac{4 \times 10 \times 100}{7}$$
$$= 571{\cdot}4 \text{ cwt.}$$

So a 10-in. by 10-in. needle should be used.

Table showing the "safe" concentrated loads at the centre of a yellow deal beam in cwt. is on page 5.

Proportion for Dead Shore

The shores supporting the "needle" should not be more than twenty times their least dimension. For instance, in Fig. 3 the shore is approximately 11 ft. 6 in. long; therefore if "die-square" stuff is used it should

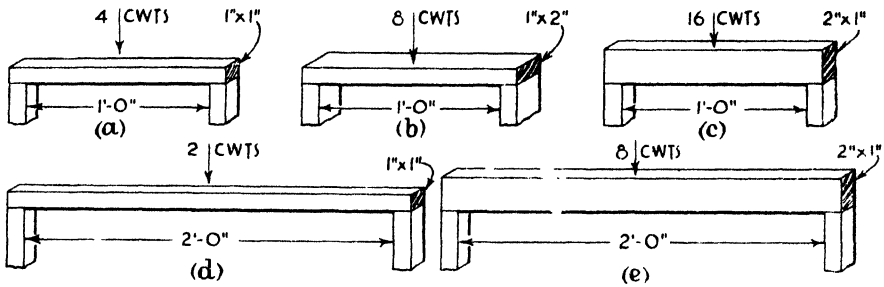


Fig. 4.—DIAGRAM SHOWING LOADS ON DIFFERENT TYPES OF SHORES

be at least 7 in. by 7 in. As the "needle" is 10 in. by 10 in. it would be more practical to use a 10 in. by 7 in., in order to have a full bearing at the top.

TABLE I.—"SAFE" CONCENTRATED LOADS AT CENTRE OF YELLOW DEAL BEAM (IN CWT.)

Size of Beam in Inches	*Span of Beam in Feet*				
	7	8	9	10	12
7 × 7 .	196·0	175·5	152·4	137·2	114·3
8 × 8 .	292·6	256·0	227·6	204·8	170·7
9 × 9 .	416·6	364·5	324·0	291·6	243·0
10 × 10 .	571·4	500·0	444·4	400·0	333·3
12 × 12 .	987·4	864·0	768·0	691·2	576·0

Note.—If the beam is subjected to a uniformly distributed load it will carry twice the weight given in the table.

A safe working stress on the end grain of yellow deal is about 900 lb. per square inch. It may often happen that the ends of a dead shore are not compressed to this extent by the load which it carries, yet it would not be advisable to reduce it in size. As stated under Dead Shore (see Fig. 2), it is buckling which is the principal danger. The following table gives the minimum dimensions for dead shores as used in Fig. 3:

TABLE II.—MINIMUM DIMENSIONS FOR DEAD SHORES

Length of Shore in feet	10	12	14	16
Dimensions in inches	6 × 6	7 × 7	8 × 8	10 × 10

Shores over 16 ft. should be braced, even if their dimensions are in the same ratio to their length as those given in the above table.

Erection of Dead Shores

For "dead shores" see Figs. 3 and 8; before the building is disturbed all floors should be supported from base to roof, to take their weight off the wall. Holes for the "needles" are then "punched" through the walls, balks laid in position to spread the weight, uprights erected and tightened by folding wedges at the top. Wrought-iron "dogs" are then driven to prevent movement at top and bottom; the wall under the needles may now be removed.

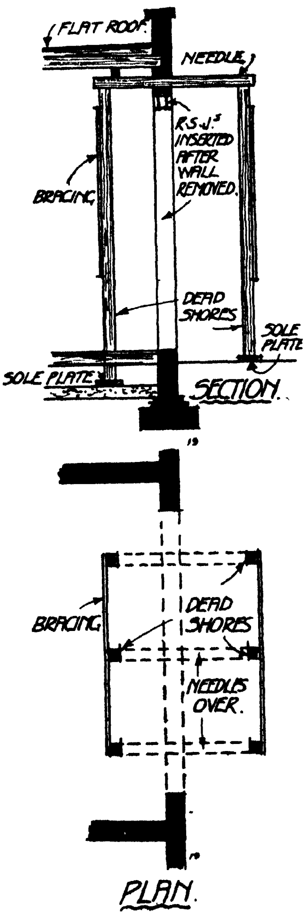


Fig. 5 (*above*).—A SIMPLE SYSTEM OF DEAD SHORING TO AN EXISTING WALL IN WHICH A LARGE OPENING IS TO BE FORMED

RAKING SHORES

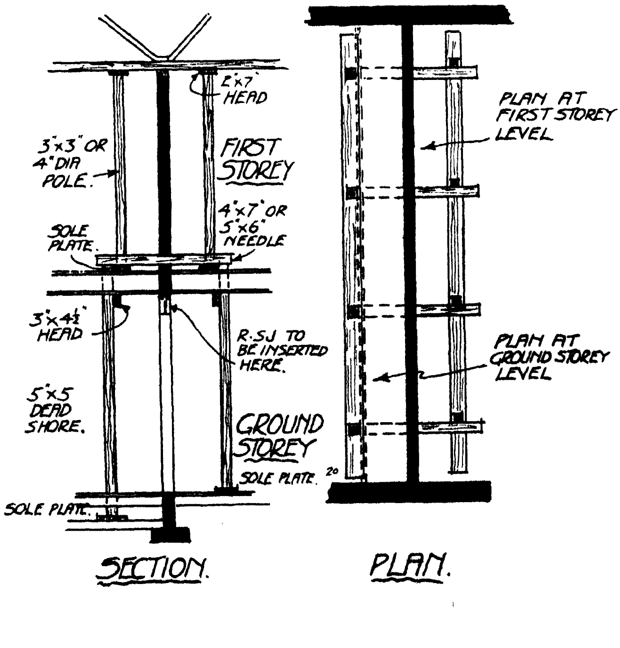
There are a variety of types of raking shores which are used according to the thrusts to be borne, the height of the wall or building to be shored, and the space available for the spread of the shores.

Single Raking Shore

Fig. 8 shows a simple type of a single raking shore.

Fig. 6 (*below*).—A SYSTEM OF SHORING THAT IS SUITABLE FOR SHORING UP ROOF, FLOORS, AND PARTITION WALL TO ALLOW FOR THE REMOVAL OF A PARTITION WALL IN THE GROUND STOREY

After the partition is removed, the rolled steel joist is inserted as shown, and then the shoring may be removed.



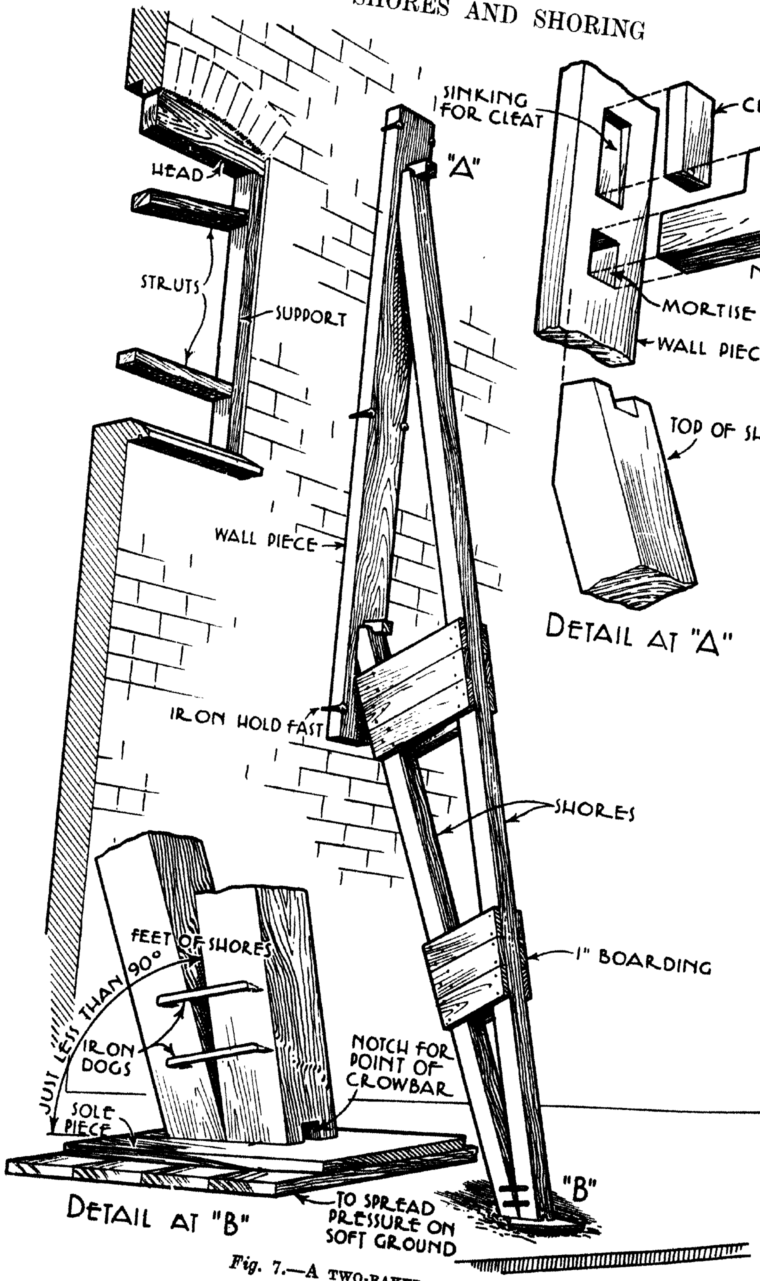


Fig. 7.—A TWO-RAKER BATTERY

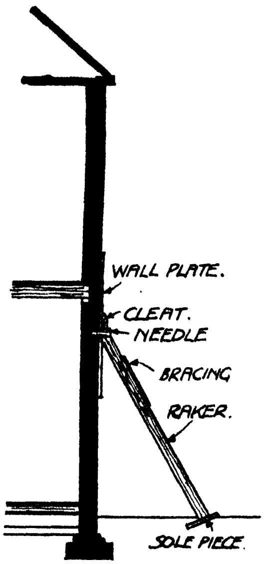


Fig. 8.—Single raking shore

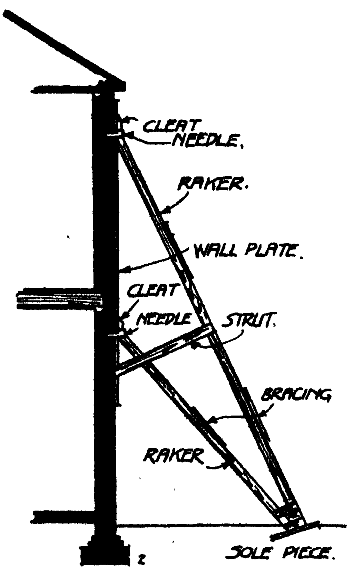


Fig. 9.—Double raking shore

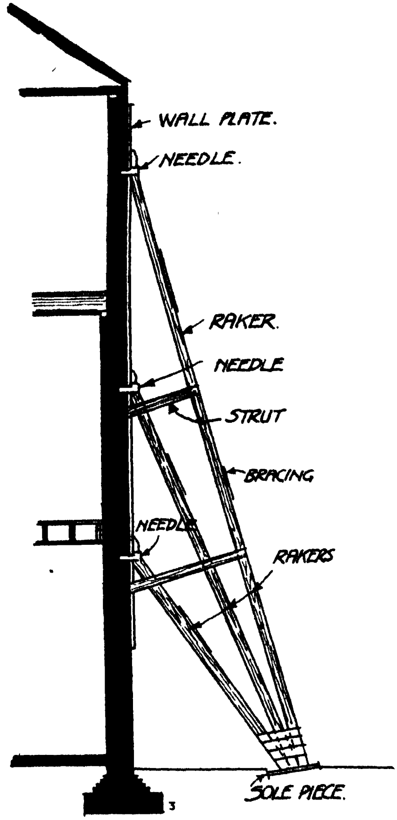


Fig. 10.—Treble raking shore

Double and Treble Raking Shores

Figs. 7, 9, and 10 depict double and treble raking shores respectively. The number of rakers may exceed three.

Spreading Treble Raking Shore

Fig. 11 shows a method of arranging the shores where there is ample space for spreading. The advantage of this system is that shorter and a less number of members may be used.

A four-shore battery is shown in Fig. 12. Difficulty in obtaining the top

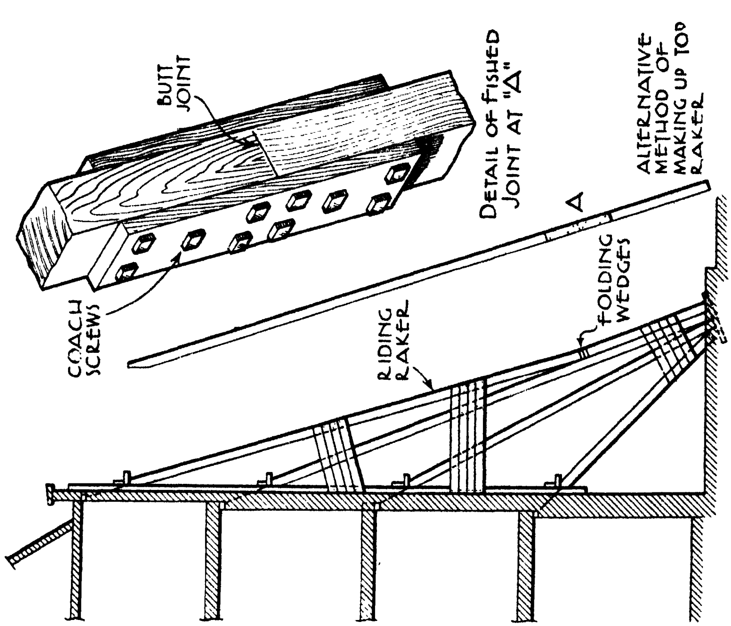


Fig. 12.—A FOUR-SHORE BATTERY

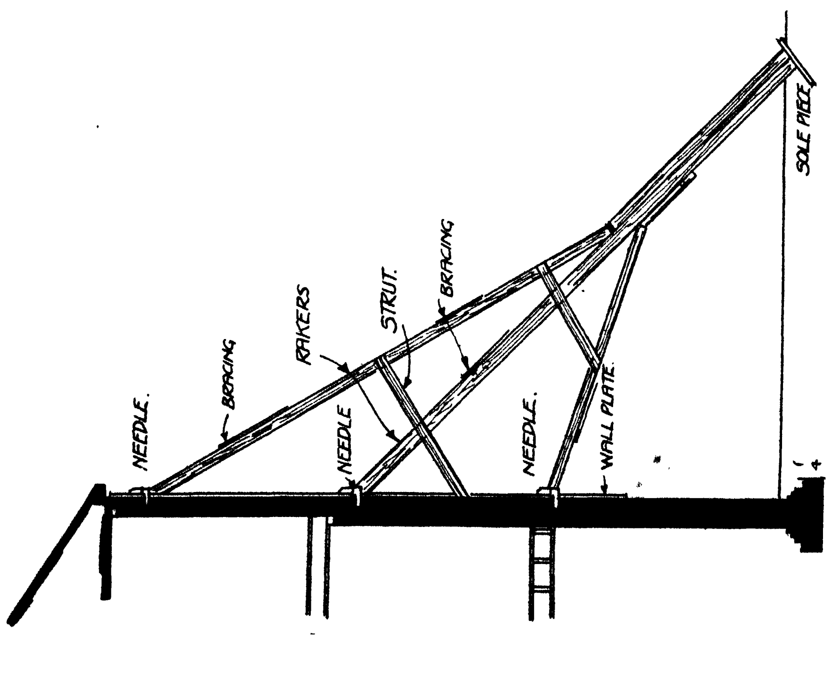


Fig. 11.—SPREADING TREBLE RAKING SHORE

raker in one length is overcome by one or other of the methods shown.

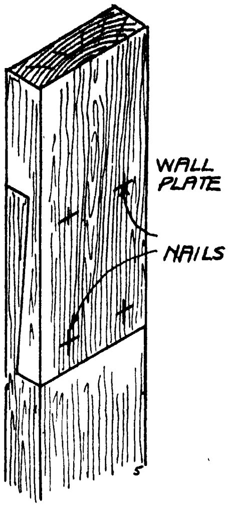


Fig. 13.—A JOINT IN A WALL PLATE SHOULD BE MADE AS SHOWN

Wall Plates

Wall plates, as shown by Figs. 7 to 11, are almost invariably used, one exception being when the load to be supported by a single shore is a point or concentrated load. The usual sizes of wall plates are 9 in. by 2 in. and 9 in. by 3 in., and they are usually fixed against and spiked to the wall with wall hooks. They are additionally supported by the rakers and needles, and extend about 3 ft. beyond the top and bottom rakers, being in one length if possible. If a joint is necessary it should be as shown by Fig. 13.

Needles

A needle is shown in detail by Fig. 14, and its object is to very securely connect the top end of

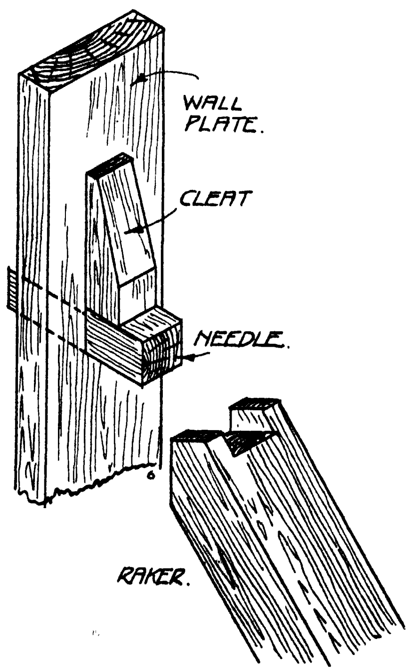


Fig. 14.—DETAIL OF NEEDLE
Showing how it is connected to the wall plate and to the raking shore.

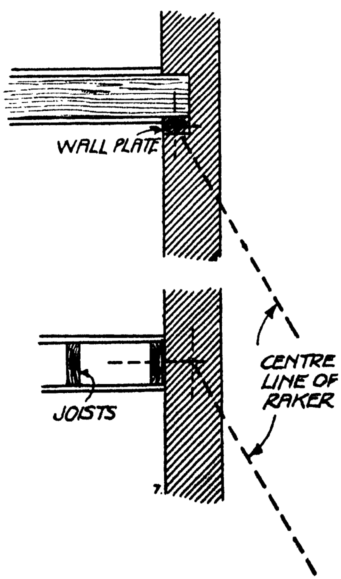


Fig. 15.—HOW THE CENTRE LINE OF RAKERS SHOULD BE ARRANGED ACCORDING TO HOW THE FLOOR IS CONSTRUCTED

a raker to the wall and wall plate, and to assist in generally binding the whole of the work together. Needles may be 4 in. by 3 in. and should preferably be of hardwood, and extend at least 4½ in. into the wall and through the wall plate, and have sufficient projection in front of the plate to allow the formation of a proper connection between it and the raker, including a cleat, as shown.

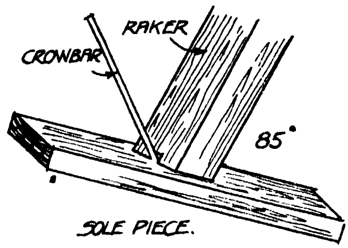


Fig. 16.—DETAIL OF JUNCTION OF RAKING SHORE WITH SOLE PIECE

The Rakers

The internal angle between the outer or top raker and the horizontal, or ground, should be 60 to 75 degrees, the former being the usual for practical purposes. Raking shores should be placed about 10 ft. apart, centre to centre, but the distance is often dictated by practical considerations, such as the position of windows and other openings which necessitates the shores being fixed against piers. Great care should be exercised in arranging the top ends of the rakers, and they should be at those points where there is an *internal resistance* to the *external pressure* of the rakers, which tend to make the wall bulge inwards. The best position to comply with this condition is at floor or roof levels. The centre line of the rakers should be as shown by Fig. 15, which theoretically assures the proper transmission of the stresses. It is advisable that shores should extend to the roof.

Base of Rakers

Fig. 16 is a typical detail of the base for rakers, and consists of a sole piece which is usually 11 in. by 3 in. bedded in an inclined position on perfectly firm ground, and set slightly *acute*, say 85 degrees, with the outer or top raker. The rakers are levered up with a crowbar, operated in a notch as shown, and securely " dogged " and cleated to the sole piece. Wedges are not advised, as knocking them into position is liable to shake the work. If the ground is not perfectly firm, the area of the sole piece must be increased by a platform of timber, so that the pressure may be distributed over a sufficient area of ground.

Strutting the Rakers

It is of vital importance, unless very heavy timbers are used in the rakers, that each raker is strutted or braced, as shown by the general drawings. The effect of the struts, or ties, is to reduce the strut length of the rakers. If there were no struts each raker would be one long strut between base and top, and as such would have a decided tendency to buckle, unless heavy timbers were used. Obviously the struts or ties prevent buckling in one direction only, that is, in the direction of the

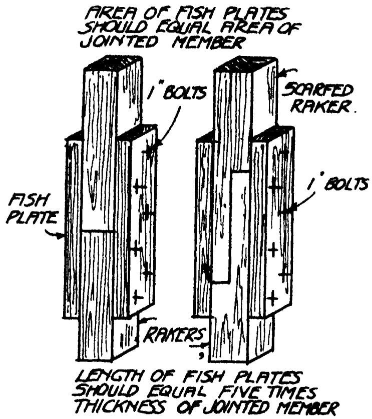


Fig. 17.—JOINTS IN RAKERS

If it is inconvenient to obtain rakers in one length and if joints are necessary they should be made as shown by this drawing.

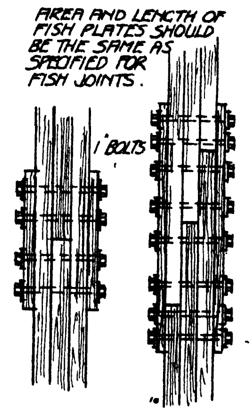


Fig. 18.—RAKERS BUILT UP WITH TWO OR THREE PLANKS

Joints may be formed as shown by this drawing.

struts, and does not overcome buckling in the other direction, but this lateral weakness is dealt with below. The struts may be 9 in. by 1½ in. or preferably 9 in. by 2 in.

Lateral Supports to Rakers

The struts, or ties, previously mentioned do not brace in the sets of shores sideways or laterally, so it is advisable to brace the sets of shores together with light scantlings or stiff boards.

Owing to the lateral weakness of shores the use of rectangular timbers instead of square, such as 9 in. by 6 in. or 11 in. by 6 in., instead of

TABLE III.—SQUARE AND RECTANGULAR SCANTLINGS FOR RAKERS

Square Inches.	*Solid Rectangular. Inches.*	*"Built-up" Rectangular. Inches.*
4 × 4	4½ × 3½	
4½ × 4½	5 × 4	
5 × 5	6 × 4 or 7 × 4	
6 × 6	7 × 5	2/7 × 2½
7 × 7	8 × 6	2/8 × 3
7½ × 7½	9 × 6	2/9 × 3
8 × 8	9 × 7 or 11 × 6	9 × 3 and 9 × 4 or 2/11 × 3
8½ × 8½	9 × 8 or 11 × 7	2/9 × 4 or 11 × 3 and 11 × 4
9 × 9	11 × 8	2/11 × 4
10 × 10	11 × 9	3/11 × 3
11 × 11	13 × 9	
12 × 12	14 × 10	

TABLE IV.—SCANTLINGS FOR RAKING SHORES OF FIR TIMBER (OR TIMBER OF NOT LESS STRENGTH)

Height of Wall in Feet.	*Number of Rakers.*	*Distance Apart of Rakers in Feet. Sectional Area of Rakers in Inches.*					*Angle of Outer Raker with Horizontal.*
		8 ft.	10 ft.	12 ft.	14 ft.	16 ft.	
		16	16	20	24	28	60 to 75
15	1	16	18	22	26	30	55
		17	20	24	29	33	50
		18	20	24	27	30	60 to 75
20	1 or 2	20	22	26	30	34	55
		22	24	29	33	37	50
		25	30	35	40	45	60 to 75
25	2	27	33	38	44	50	55
		30	36	42	48	54	50
		33	40	46	52	58	60 to 75
30	3	36	44	50	57	64	55
		40	48	55	62	69	50
		42	50	58	64	70	60 to 75
35	3	46	55	63	70	77	55
		50	60	70	77	84	50
		53	64	75	86	97	60 to 75
40	3 or 4	58	70	82	94	102	55
		63	77	90	102	114	50
		60	72	84	96	108	60 to 75
45	4	65	78	92	105	118	55
		72	86	100	115	130	50
		66	80	94	108	122	60 to 75
	4 or 5	72	87	103	118	135	55
50		79	96	113	130	147	50

Wall Plates: 9 in. by 2 in. up to 30 ft. height of wall; 9 in. by 3 in. over 30 ft. high.
Struts: 9 in. by $1\frac{1}{2}$ in. or 2 in. in positions shown by Figs. 9, 10, and 11.
Sole Piece: 11 in. by 3 in.
Needles: 4 in. by 3 in. or 4 in. by 4 in.

The scantlings shown are suitable for new or sound second-hand timber. If the timber is old and only in fair condition, then use scantlings shown for a height of wall that is 5 ft. greater than the actual.

Any special circumstances or specially dangerous work may need increased sizes of timbers and arrangement of the various members.

7 in. by 7 in. or 8 in. by 8 in. is recommended, as it is then possible to so dispose the timbers with the lesser dimensions in the direction where the *strut length* is *shorter*, and the greater dimensions where the *strut length* is the *greater*.

Joints in Rakers

It is best that rakers be in one length without a joint, but if joints are essential they should be very strong "*fished*" or "*scarfed and fished*

joints," as shown by Fig. 17. If rakers are constructed with two or more planks, an economical and effective joint may be formed by well lapping the joints by the adjacent plank, or planks, and "fishing," as Fig. 18.

Scantlings for Raking Shores

The Table IV allows for proper sizes of raking shores set at angles of 50 to 75 degrees from the horizontal, various centres of the sets of shores and for different heights of walls and number of rakers. Particular attention should be given to the notes at the bottom of the Table.

Square and Rectangular Scantlings

The Table III indicates the best *rectangular sections* compared with *square sections.*

Erecting Raking Shores

" Headers " are cut out near where the top and bottom of the wall piece will come. Mortices are made in the wall piece to coincide with the holes cut in the brickwork, and the wall piece fixed in position with " hold-fasts." A sole piece is then bedded as shown, the needles and cleats fixed in the mortices, the rakers fitted, hoisted, and levered tightly under the " needle " by a crowbar. The struts or boarding are nailed across as shown. This has the effect of stiffening the " battery " against vibration, and making the " rakers " react in unison.

FLYING SHORES

When a building has to be entirely demolished, as suggested in Fig. 19, the party walls of the adjoining property will have to be supported. If these walls are not too far apart " flying shores " are erected as shown in Fig. 19. " Single " and " double flying shores " are shown. It will depend on the condition and height of the walls as to which of these shall be used. The position of the " shores " will depend on the arrangement of the new premises ; but they must be so placed that permanent support is given by the new walls before they have to be dismantled. Their erection up to a certain point follows that for " raking shores," i.e. " wall pieces," " needles," and " cleats " are fixed, then the " horizontal

TABLE V.—SCANTLINGS FOR FLYING SHORES

Span in Feet.	*Horizontal Shore. Inches.*	*Struts. Inches.*	*Straining Piece. Inches.*	*Wall Plate. Inches.*
Up to 20 . . .	6 × 4	4 × 4	4 × 2	9 × 2
„ „ 25 . . .	6 × 6	4 × 4	4 × 2	9 × 2
„ „ 30 . . .	9 × 6	6 × 4	4 × 2	11 × 3
„ „ 35 . . .	9 × 9	6 × 6	6 × 2	11 × 3

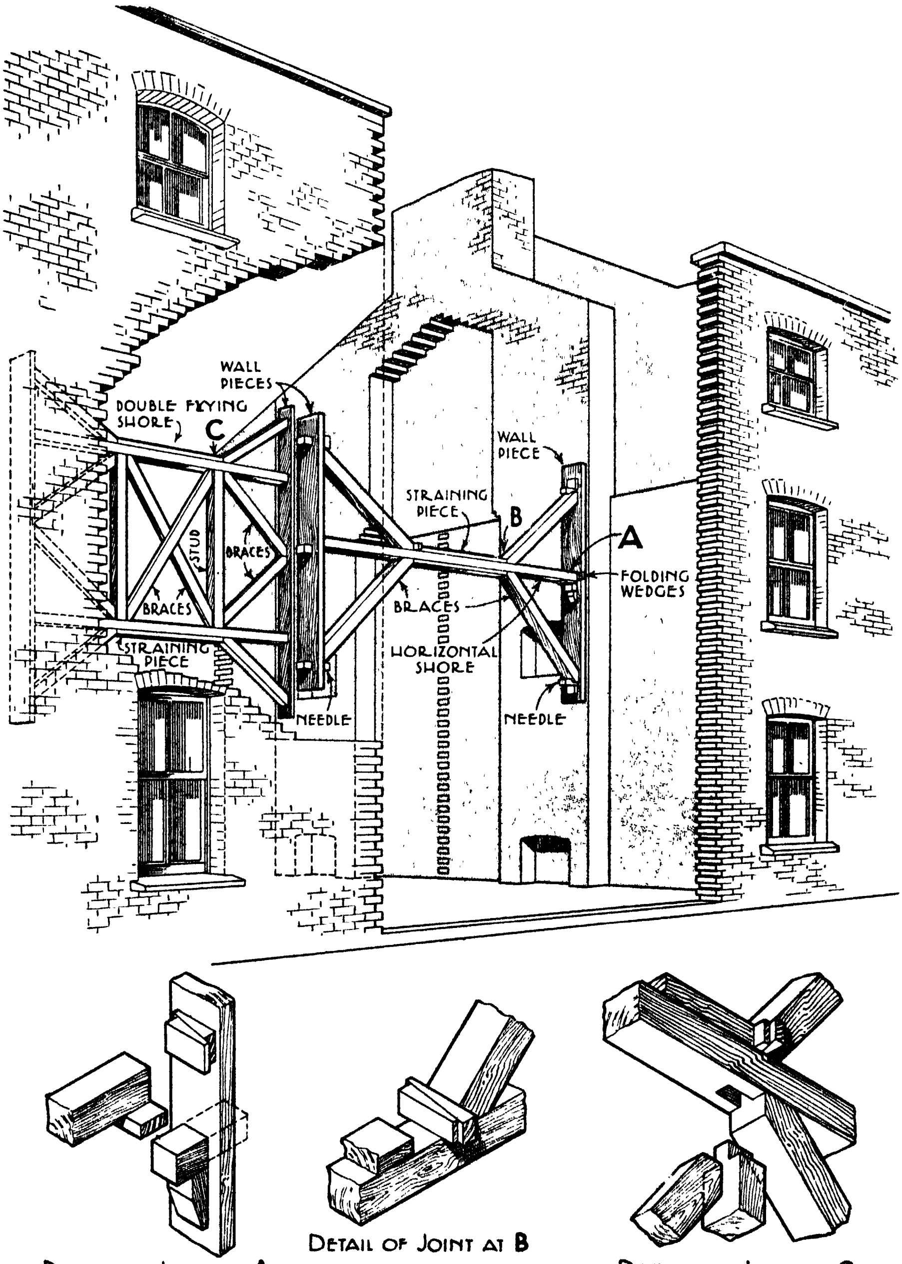


Fig. 19.—Single and double flying shores

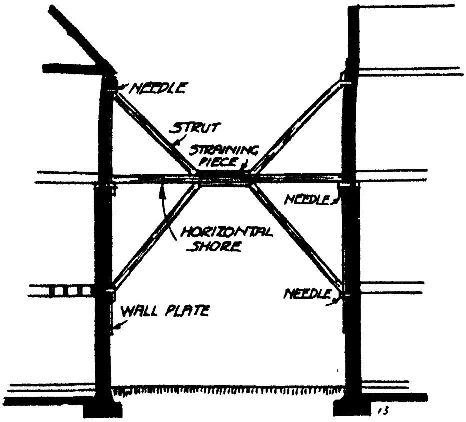


Fig. 20.—A SINGLE FLYING SHORE

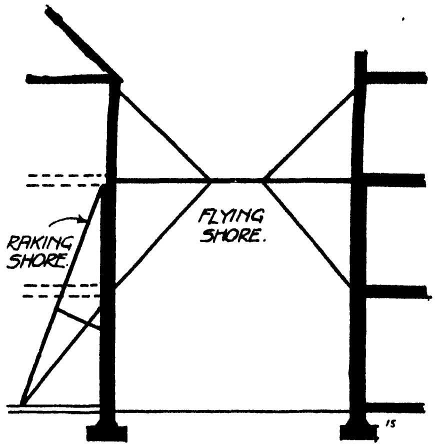


Fig. 21.—COMBINATION OF RAKING AND FLYING SHORES

In cases such as this, floors, as shown dotted, have to be removed.

shore" is laid on the "needle" (see detail at joint A), and the folding wedges tightened. The under braces and "straining-piece" are fitted as tightly as possible to remove any "sag" of the "horizontal shore." If a slight "camber" can be induced, so much the better. When the top braces and top straining-piece are in position, and the folding wedges tightened (detail at joint B), the whole framework will be tightened up, tending to make the "horizontal shore" sag; hence the precaution when fixing the braces underneath.

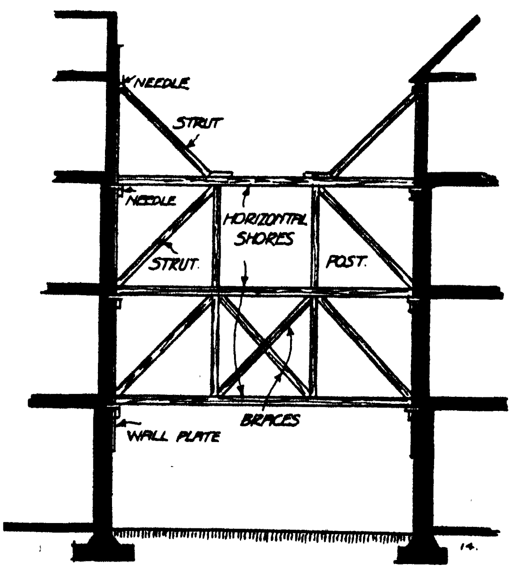


Fig. 22.—A COMPOUND FLYING SHORE

In some practical cases it is necessary to have a combined system of flying and raking shores, as shown diagrammatically by Fig. 21, such a case being where the internal walls and floors of one building have to be removed without demolishing the external wall, and this

necessitates the wall being shored from both sides, either by raking shores on both sides or by rakers on one side and flying shores on the other.

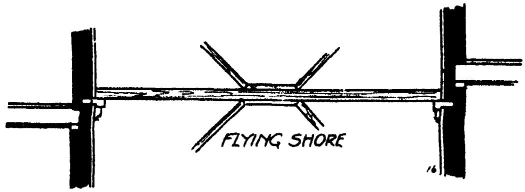


Fig. 23.—HORIZONTAL SHORE

Where both floors are supported by the walls to be shored, and the floors are at different levels, then the horizontal shore should be placed as shown.

General Details

The wall plates, needles, bases, cleats, and struts should accord to the principles of raking shores.

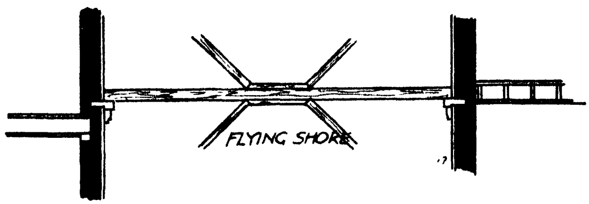


Fig. 24.—HORIZONTAL SHORE

Where one wall supports a floor and the other wall does not, the horizontal shore should be placed as shown.

Varying Floor Levels

Where the floors of both buildings are the same level there is no difficulty in deciding where the horizontal shores should be placed. Where the floor levels vary, say by 1 or 2 ft., the best position of the horizontals requires consideration. Where the floor joists run parallel to both walls, or if both walls support the joists, the horizontal should be placed between the two floor levels, as shown by Fig. 23. Where the joists are supported by one wall and are parallel to the other, then place the horizontals as Fig. 24. There is no harm in placing the horizontal members a little out of level in cases where there is but little difference in floor levels.

How to Erect Flying Shores

The shores must be constructed either before or during the demolition of a building. It is usual to construct them as the demolition proceeds from the top of the building. They should be removed as soon as any new work is of a sufficient height to make shoring unnecessary.

The horizontal shore is fixed between the two wall plates, and if there is a space between the shore and plates, a pair of folding wedges must be inserted and lightly driven home.

The straining pieces which form abutments for the struts should be 2 in. thick and same width as the struts.

The struts should be fixed as nearly as possible to an angle of 45 degrees, and cut tightly in between straining pieces and needles. They should be additionally tightened by folding wedges driven in between the

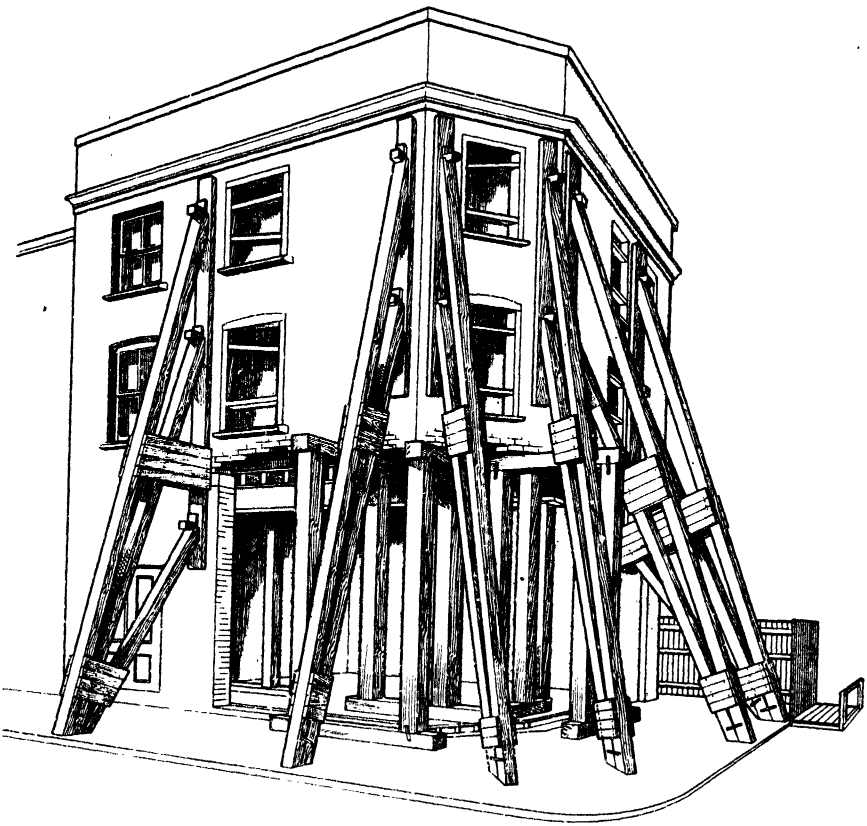


Fig. 25.—Shoring for conversion of house to shop

struts and straining pieces on the upper side, which will cause the horizontal shore to deflect a little, and so stiffen the lower struts and the whole framing.

Scantlings for Flying Shores

The Table V gives sizes of various members for different spans. Special conditions may require greater sizes.

Conversion of House to Shop

In a flat wall, where the shop front is a matter of from 12 to 15 ft. long, " dead shores " alone may be used to take the weight of the brickwork over (see Fig. 5); but for longer stretches, or at a corner as shown in Fig. 25, " raking shores " should also be employed. In addition to the preliminaries stated under *Erection* all window sashes should be removed,

TABLE VI.—SAFE LOADS ON TIMBER STRUTS
In cwt. (112 lb.)

Size	Height of Strut in feet								
	8	10	12	14	16	18	20	22	24
in. in.	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.
4 × 4	44	29	20	15	11	9	7	6	
4 × 6	66	43	30	23	17	13	11	9	8
4 × 9	99	65	46	34	26	20	17	14	12
6 × 6	171	129	99	76	57	46	36	31	26
6 × 9	256	194	148	114	86	69	54	47	39
9 × 9	567	440	385	315	260	222	182	158	129
9 × 12	735	605	513	432	345	297	243	274	230
12 × 12	1,195	1,040	900	775	683	597	517	457	390
14 × 14	1,690	1,568	1,370	1,225	1,100	955	840	755	665

These figures are for sound fir of ordinary quality.

TABLE VII.—SAFE UNIFORMLY DISTRIBUTED LOAD ON ROLLED-STEEL JOISTS USED AS BEAMS

Size	Weight per foot	Span in feet												
		6	8	10	12	14	16	18	20	22	24	26	28	30
in. in.	lb.	tons	tons	tons	tons	tons	tons	tons	tons	tons	tons	tons	tons	tons
3 × 1½ . .	4	1												
3 × 3 . .	8½	2												
4 × 1¾ . .	5	2	1											
4 × 3 . .	10	3	3											
5 × 3 . .	11	5	4	3										
5 × 4½ . .	20	9	7	5										
6 × 3 . .	12	6	5	4	3									
6 × 4½ . .	20	10	8	6	5									
6 × 5 . .	25	13	10	8	6									
7 × 4 . .	16	10	8	6	5									
8 × 4 . .	18	12	9	7	6	5	5							
8 × 5 . .	28	20	15	12	10	9	7							
8 × 6 . .	35	26	19	15	13	11	10							
9 × 4 . .	21	16	12	10	8	7	6	5						
9 × 7 . .	50	41	31	25	21	18	15	14						
10 × 4½ . .	25	22	16	13	11	9	8	7	7					
10 × 5 . .	30	26	20	16	13	11	10	9	8					
10 × 6 . .	40	36	27	22	18	16	14	12	11					
10 × 8 . .	55	51	39	31	26	22	19	17	15					
12 × 5 . .	32		25	20	16	14	12	11	10	9	8			
12 × 6 . .	44		35	28	24	20	18	16	14	13	12			
12 × 8 . .	65		54	43	36	31	27	24	22	20	18			
13 × 5 . .	35			23	19	17	15	13	12	11	10			
14 × 6 . .	46			41	34	29	25	23	20	18	17	15		
14 × 8 . .	70			54	45	38	34	30	27	24	22	19		
15 × 5 . .	42			30	25	22	19	17	15	14	13	11		
15 × 6 . .	45			35	29	25	22	19	17	16	15	12		
16 × 6 . .	50			41	34	29	26	23	21	19	17	15	13	
16 × 6 . .	62			48	40	35	30	27	24	22	20	17	15	
16 × 8 . .	75			65	54	46	41	36	32	30	27	23	20	
18 × 6 . .	55			50	42	36	31	28	25	22	21	18	16	14
20 × 6½ . .	65			65	54	47	41	36	33	30	27	23	20	18
24 × 7½ . .	95			113	94	80	70	63	56	51	47	40	35	31

When used with load concentrated at centre as for needles, HALVE THESE LOADS.

TABLE VIII.—SAFE LOADS ON ROLLED-STEEL JOISTS AS STRUTS

Weight per foot	Size	Height of Strut in feet						
		8	10	12	14	16	18	20
lb.	in. in.	tons	tons	tons	tons	tons	tons	tons
10	4 × 3	7	4					
11	5 × 3	7	5					
20	5 × 4½	24	18	14	10			
25	6 × 5	33	25	18	15			
18	8 × 4	16	10	8				
28	8 × 5	36	28	20	16	12		
35	8 × 6	56	46	37	30	24	20	16
21	9 × 4	18	13	10				
25	10 × 4½	27	20	15	10			
40	10 × 6	62	50	40	32	25	20	
55	10 × 8	100	90	80	67	57	48	40

and window openings firmly strutted as shown to keep the structure as rigid as possible.

Hoardings

When shores or hoardings encroach on the public way a licence for their erection must be obtained. A portion of a hoarding, with temporary footway and guard rail, is shown in Fig. 25. Their construction does not require explanation. They must be made safe for pedestrians, and should not impede the flow of storm water in the gutter. Where road gullies occur, suitable access to these should be provided.

To Calculate Weight of Building when Shoring

Measure area of wall:	cwt. per sq. ft.
For 9-in. wall, allow	¾
,, 14-in. ,, ,,	1¼
,, 18-in. ,, ,,	1½

Measure area of floor borne by wall being shored:	
For extra-heavy floors, and in storage buildings, allow	2
For concrete-and-steel-joist floors, allow	1½
For floors of large area with wood joists, allow	1¼
For light floors of wood, allow	¾
For heavy flat roofs, including ceilings, allow	1¼
For slate or tile pitched roofs, allow	½

Chapter II

LIFTING EQUIPMENT FOR BUILDERS

THE sole purpose of lifting tackle, whatever its nature, is to enable men to lift heavier loads more rapidly than is possible by their unaided efforts. Despite the advances made in such equipment, the Babylonian gin wheel is still with us, and we still refuse to accept the full advantages which can be gained by correct choice and use.

Choice of Lifting Equipment

Too often purchase is in the hands of those with little practical knowledge or with too great a regard for the twin gods Low Price and Discounts. Betwixt the Scylla of too high a price and the Charybdis of too low a price there is a happy mean where the builder can find appliances which, used intelligently, will make all the difference in that race for profit where all seem to be equally handicapped by wage and material costs.

The Gin and Fall

The simplest lifting device is the gin and fall. The former can be very good or very bad. The usual practice, of supply stores, is to purchase wheels and frames separately, assembling them by the use of a common black hexagon bolt and nut. Neither the material nor the method is good; the pin should be properly made from good steel, formed with a large flat head on the one side and provided with a substantial split pin or keep on the other. In addition the pin should be drilled lengthwise to connect with a radial hole of about ⅛ in., so that lubricant can be forced to where it is wanted instead of being poured promiscuously over the sides of the frame.

The writer has used ball-bearing gin wheels with excellent results, the effort necessary to raise a load being greatly reduced and the lowering speed of the empty rope increased.

Practical Notes on Fall Ropes

Fall ropes can be bought in a variety of material. The truest economy here is to purchase from one of the large rope-making combines, the smaller makers and importers being apt to use vegetable fibres which are too short to form a strong rope or lacking in that elasticity which is so essential to long life.

Ropes should be kept coiled and hung in a cool dark shed, and at the first signs of wear of the outer fibres should be renewed.

Although cheaper when bought by the coil, there is the danger of

decay. Bought as required, they are more likely to be cut from a new coil and to last the longer.

Use is now being made of gin wheels using wire rope, from a miniature power-driven winch, for loads up to 2 cwt., and once again the rope is best purchased from a large supplier.

Wire Ropes

Wire ropes should be of galvanised steel to prevent corrosion, have a factor of safety of six times their working load, and be built of a sufficient number of strands to make them flexible enough to pass easily around the wheel on which they are to be used. Failure to observe this point leads to rapid opening of the wires, but it can always be avoided by consulting the makers.

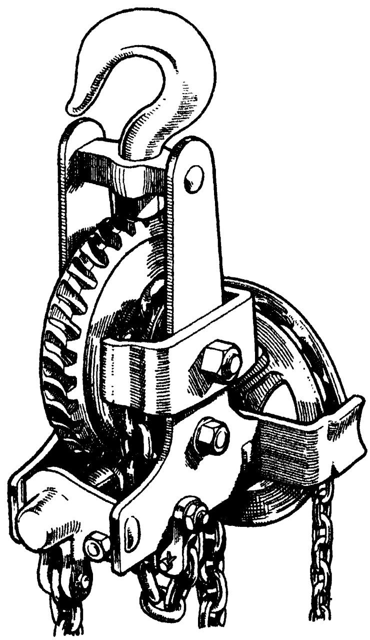


Fig. 1.—A TYPICAL PULLEY BLOCK

Thrust on the worm applies a brake automatically.

Snatch Blocks

Snatch blocks, like gin wheels, are to be bought with ball bearings. Not only do they run more freely, but they can be grease-packed before going out to a job, with the certainty that they will then be properly lubricated throughout their period of use.

What to Avoid

Too frequently base snatches are buried in debris and never cleaned or oiled, so that a plain bearing rapidly wears oval. Several fatalities have been traced to the tying down of snatches in such a way that the frame was unable to pivot and allow the rope to follow the angular changes as it laid along the winch drum. As a result, the rope was skidding on the side of the frame.

The difference in price between ball-bearing and plain snatches is so small that the former are well worth the additional outlay.

Pulley Blocks—Modern Types

For occasional lifting of heavy loads the most-used appliance is the pulley block, which can be fitted with chain, manila, or wire rope, the two latter being more suited to light loads not exceeding half a ton.

Chain pulleys may be of the spur gear, worm gear, or differential type, the latter being by far the worst in every way. All depend for their

lift on the fit of chain links in suitable recesses formed in a grooved wheel, and this fit being essential to their safety, it is well to realise the commonest cause of failure.

Chains and Their Care

Chains are constructed of links forged by hand or machine from round iron rod of such a diameter as to give sufficient tensional strength for the loads they are to lift. Each link is welded and formed in the shape of a capital O, but, being elastic, loads tend to lengthen the links, thus bringing the sides closer together.

If excessive this load will tend to crack the weld and to distort the link, so that it will no longer fit its recess and will then tend to jump. Foremen always strenuously deny that they have overloaded a tackle, but in lifting a frequent mishap is the sudden application of double the load supposedly lifted owing to its slipping from its resting position into a state of actual bearing in the sling. This is very likely to happen when picking rolled-steel sections off biats and results in unnoticed link distortion. All chain tackles and chain slings should be sent at least once a year to a qualified testing works for examination and annealing.

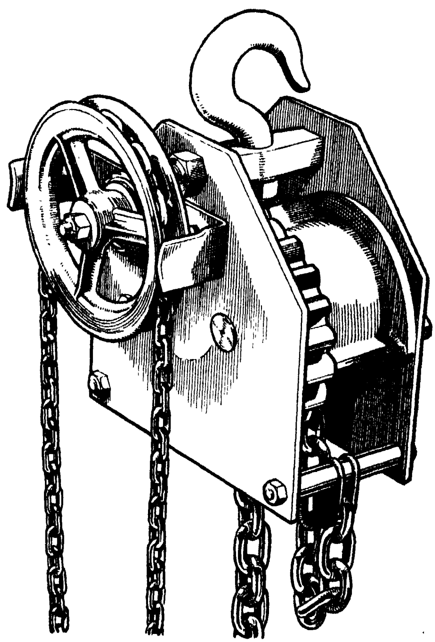


Fig. 2.—Spur-geared pulley block

The end link of any sling should be stamped with the date of test and the working load for which it is suited, and in no circumstances should users encourage the pernicious habit of annealing by heating in a blacksmith's forge or incinerator fire. Some links will be correctly heated, but others will be too quickly cooled by accidental draughts, thus setting up unequal stresses in the metal. In addition to this only skilled men are competent to detect the earliest signs of weld or link failure.

Further Notes on the Use of Pulley Blocks

Reverting to the condemnation of the differential tackle, it is not always realised that the hand chain serves also as the lifting chain and therefore travels much farther than does the lifting chain in other types

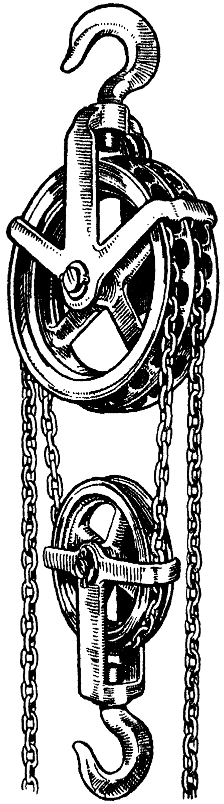


Fig. 3. — DIFFERENTIAL PULLEY BLOCK

of pulley block. This makes for rapid wear, lack of fit in the chain recesses, and consequent jumping.

Of the two types, spur gear and worm, whilst the former is very efficient and well protected from dirt in its working parts, it is high priced. Builders' pulley blocks spend so much of their lives in the plant shed that this extra cost is hardly worth while, and the worm-geared type is probably the better on an all-round view.

Complaints are frequently received of a tested worm block slipping on its first job after a test. Generally this is due to careless or over-enthusiastic lubrication, because the load is sustained by the end thrust of the drive worm being brought to bear on a leather brake pad which becomes slippery when over-oiled. A spot of petrol will cure the trouble in a few moments.

There are many cheap worm-geared blocks, but few are satisfactory. Their working loads are often marked in kilograms, which is confusing; their chains are made from low-grade iron, which has to be of excessive diameter to stand their working stresses ; their frames are cumbersome ; the worms and worm wheels are badly cut and sometimes even cast ; they absorb too much work in friction, and, lastly, they nearly all hang badly, owing to wrong disposition of the parts, the centre of load coming to one side of the suspension hook. Without a doubt they are a bad investment.

Worm-geared Block with Gravity Lowering Device

If the best is wanted, a worm-geared block with gravity lowering device is advised, as it saves an enormous amount of time otherwise spent in lowering by hand at the same speed with which the load is picked up. The builder's requirements are best met by a two-ton block with a lift of 20 ft., this covering the normal lifting of rolled-steel bressummers and the like.

The Wedge-lock Block

For light lifts, such as stonemason's work on cills, steps, and so on, the wedge-lock block using manila rope will be found a useful tool. The illustration shows one of these, and if preferred they can be fitted with wire rope. The return and running ropes ride over two pulleys in such a way that they nearly touch. By pulling the control cord a wedge is

lowered into the gap, where it is drawn more tightly as the load increases, thus giving a convenient holding device which allows of accurate setting of the stone.

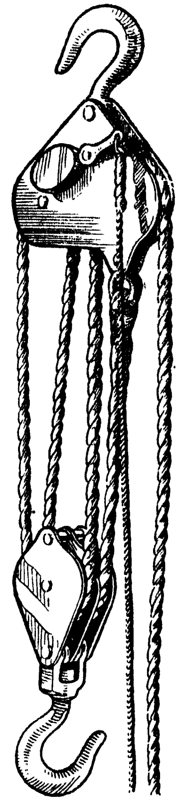


Fig. 4.—WEDGE-LOCK PULLEY BLOCK

The hand cord actuates the wedge and locks the load.

Jacks

Jacks are essentially emergency tools. Comparatively rarely used, spending most of their life in store, they are the Cinderellas of the plant shed, yet no item of a builder's equipment needs such care in purchasing.

So many builders are motorists and have had experience of cheap car jacks, that it is difficult to understand how rapidly they forget this experience when buying a jack which may endanger the safety of a whole building or the life of a workman.

The Ship-type Hydraulic Jack

Given carte blanche by the purchasing department, the best of all jacks for the builder is probably the ship-type hydraulic. It is light, has a large flat base, is smooth in action, and has few parts likely to deteriorate in store. One objection raised to them is that they have a limited lift as compared with bottle or ratchet types, but they are so easily lowered under load that they can be packed up as the work proceeds with a minimum of difficulty and with absolute security.

Jacks can be bought which have a useful addition in the shape of a bottom foot or claw, which often enables them to be got under awkward loads, but unless the base is broad enough to bring the foot load well inside the base they are inclined to tilt and jam their bodies against the load, thus setting up a case of an "irresistible force trying to shift an immovable body."

Hoists

The use of an engine-driven winch, combined with an overhead snatch block and barrow slings, to lift concrete and the like up the face of a board apron fixed to the scaffold is, owing to the contorted but compulsory rings and the juggling necessary to land a barrow, so time-wasting that we will ignore this method and deal with the modern power platform hoists.

Power Platform Hoists

Whilst these are now familiar sights on any large building contract and can be bought in a variety of forms suited to specialised tasks, the average user knows little enough of what constitutes an efficient hoist.

The usual layout comprises a small petrol, or crude-oil, engine geared

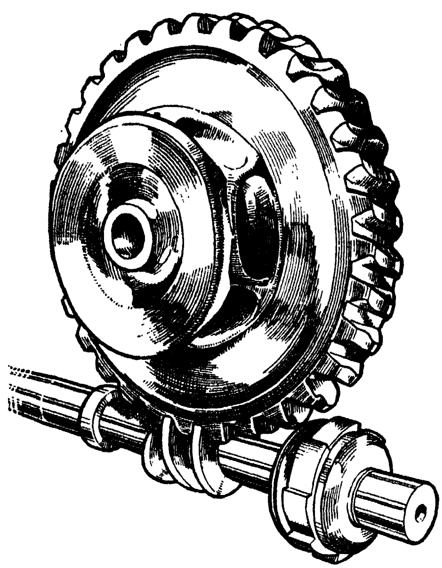


Fig. 5.—WORM-GEARED CHAIN PULLEY BLOCK.

to a winch carrying a length of steel wire rope which serves to draw a platform up suitable rails or runners attached to the scaffolding.

They may be roughly divided into two classes: those with platforms moving always in the same vertical plane; and those with rotatable platforms, which have the apparent advantage of being turnable about a vertical axis so as to swing the platform directly inwards and over the actual interior decking of the scaffold.

Practical Notes for the User

To use these latter to the best advantage needs considerable skill on the part of the driver, who, if he is not to lose time on every journey, must so handle the clutch mechanism of the winch as to bring the platform just sufficiently above, but not too high above, the landing at which he is aiming, as to avoid collision when the platform is swung around inwards and/or a dangerous impact when he lowers the platform from its too high position to a state of rest on the scaffold.

As a platform with one or two loaded wheelbarrows might weigh around 15 cwt., impact is not an over-estimated danger, particularly with modern forms of grip connections on steel tubing, whatever it might be with the older but more resilient pole scaffold.

Any advantages accruing to a landing inside the scaffold would seem to be offset by the danger of obstruction on what is usually a traffic-congested path.

In lowering the platform it becomes necessary first to raise it, then swing it outwards, then lower; three actions cannot be performed as rapidly as one and, as will be seen later in this section, it is possible to avoid both this lost time and the obstruction difficulty by the use of other forms of hoist.

Selecting a Power Hoist

Such rotating platform machines as are sold in this country are usually of the central mast type, the mast being constructed of tube, channel, or other convenient rolled-steel section, the mast being provided with a flat metal base to give a firm support. Care should be taken to

see that if a mast hoist is purchased its base is of such a shape as to allow the platform to come level or nearly level with the ground when at its lowest point. Some Continental hoists come to rest as far as 2 ft. 6 in. above ground level, necessitating the use of timber ramps, up which the loaded wheelbarrows must be wheeled, or the use of a pit in which the base can be set. Difficulties in the way of drainage, attention to the base snatch block, and the steep angle at which the haulage rope runs to the winch drum make this an extremely unhandy design which is best avoided.

Another difficulty with badly designed central masts is that the platform frame being guided in its vertical movement by rollers running on the mast, a considerable danger of side swing exists. With a 6-in. mast, wear of as little as ¼ in. at the rollers can be magnified at the edge of a 5-ft. platform to several inches. If the hoist runs sideways to the scaffold, as is often the case, a barrow wheel passing from staging to platform can exert a wedging action which will force a gap of as much as 9 in., with dangerous results.

In the non-rotating type of platform use is made of rail sections in convenient lengths, varying from 9 ft. to 16 ft., each section being built of two parallel tees serving as actual rails, and two tees or channels serving as support members, joined at intervals by C-shaped forged pieces at distances of about 5 ft.

This form provides good resistance to swaying and bending, a wide track or gauge for the roller guides thus preventing side swing of the platform and allowing easy assembly by suitable fish-plates.

In choosing between makes which use different-weight sections, it is better to decide on the heavier one, as the sections are often subjected to severe strains whilst being transported from job to job.

Setting up a Power Hoist

Fixed platform hoists can be set up in a variety of ways: back to the scaffold; sideways; facing it, or inside an independent tower. If set back on, it is necessary to cantilever platforms at each scaffold stage for the taking off of the loads, and for this reason alone it seems better to set the hoist to run sideways-on, the only objection being that wheelbarrows must be wheeled on to the platform at the bottom and *reversed*, so that the handles present themselves conveniently for drawing off at the top. This avoids the need for men walking round the barrow on the platform which, in addition to being contrary to Home Office regulations, has resulted in several fatalities.

A small wood chock nailed to the floor of the platform will serve as a guide stop for the wheels and prevent barrow handles being left protruding beyond the line of the scaffold.

The independent tower has the advantage that men can get all round the platform; that there is no obstruction to the staging; that the

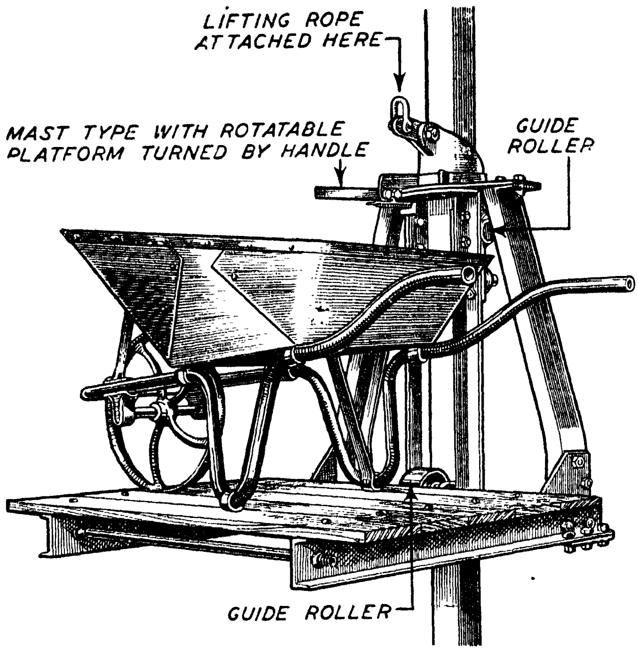


Fig. 6.—Mast type hoist
With rotatable platform turned by a handle.

scaffolding can be removed at any time without interfering with the hoist.

Notes on the Power Unit

Having decided on the best type of mast or rail and platform, attention should be given to the choice of motive power.

This may be steam, compressed air, electric or internal-combustion engine, the latter being the usual. Decision as to the best type of internal-combustion engine may be assisted by a study of several hoist makers' catalogues, the almost universal recurrence of one particular name being an indication of its qualities.

The Petrol Engine

The four-stroke engine is probably superior to the two-stroke, the parts being sturdier and its action more familiar to the average builder's employee. Its petrol-air mixture is also less liable to fluctuation. Ball or roller bearings should be insisted on for the main bearings at least, the fine grit and dust inseparable from builders' work being fatal to white-metal linings. Nothing but disappointment can follow neglect of this point.

For small hoists, with engines up to and including 9 h.p., the petrol engine has the advantage of simplicity, which makes the fuel economy of the so-called Diesel engine a problematic saving despite the low cost of fuel oil as compared to petrol. The latter is readily obtainable in any part of the United Kingdom, and in the standard 2-gallon cans presents no difficulties in the way of storage or compliance with Home Office regulations.

The Diesel Engine

Fuel oil for compression-ignition, that is, Diesel or semi-Diesel engines, must be purchased in bulk, but where a hoist is to carry loads of one or

one and a half tons or over the fuel saving is considerable, and where users can be dead certain of rapid repair service, Diesels are satisfactory. The fuel-injection pump, which forms the most important part of these engines, is sealed by the maker, and even if it were not, is so accurately constructed and assembled that its repair calls for skill far beyond that of even a good driver. This fact will be appreciated when it is realised that at each stroke it must deliver a portion of fuel approximating in size to the head of a pin and that any variation either way means trouble.

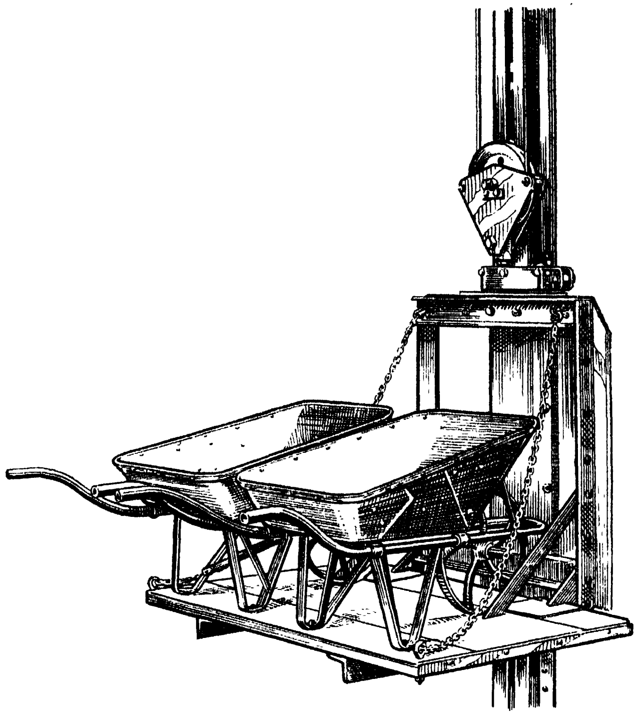


Fig. 7.—ROTATABLE TWO-BARROW PLATFORM
Note the two-part rope giving double load but halved speed of lift.

A Note on Fuel

Before leaving the question of fuels, it should be pointed out that near-petrol mixtures are not satisfactory as a rule as a substitute for petrol. The saving of even sixpence a gallon is too often lost, owing to break-downs due to sooted sparking-plugs.

Operating Notes

As the only time a hoist is a nuisance is when broken down, every care should be taken to avoid such contingencies. The loss of time by the men depending upon the hoist is serious, but not so serious as an interruption in the placing of concrete in an important load-carrying beam. Foremen are still to be found who prefer the centuries-old but reliable gin wheel and fall, owing to some bitter experience of this sort.

Without exception, every engine driver should be given half an hour's overtime after every working period for the purpose of allowing thorough cleaning and lubrication of his charge. Due attention should be given

to Saturdays, when the twelve o'clock whistle seems to have an overpowering effect. Despite the adage concerning whitened sepulchres, a clean engine is usually free from trouble.

Periodical Inspection

The contractor's engineer or plant superintendent should make a thorough inspection each month, as men are often afraid to report incipient trouble for fear of being blamed for what may be fair wear and tear.

Steam and Compressed Air

Steam and compressed air as motive powers are more usual on very large contracts carried out by engineering firms whose technical staff is too competent to need advice from outsiders, but electric drive is becoming popular enough with smaller firms to merit some attention.

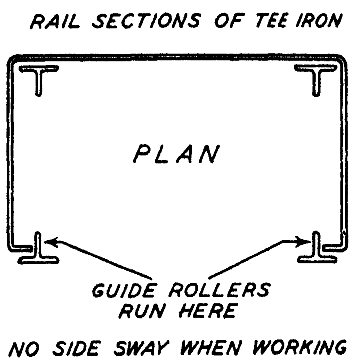


Fig. 8.—In non-rotating types of platforms use is made of rail sections

Electric Drive

Its advantages are extreme freedom from break-down and reduced maintenance, but in adopting it care must be taken to see that current can be procured at a low price. Special power circuits are necessary and in some districts the charges are high. There is at the present moment some talk of regulations forbidding the use of higher working voltages than 100, which will need care in the selection of a suitable motor.

The Power Transmission

The next point of importance concerns the drive from the engine to the winch drum. This combines a gear reduction with a clutch for disengaging the power. The former may be by worm, spur gear, belt, chain and chain sprocket, or by some type of friction drive.

Whilst the latter can also be made to serve as a clutch by separation or contacting of the frictional surfaces, the four methods first mentioned necessitate the use of a separate clutch. These are of car form, in which a Ferodo-lined male member is forced into a coned female, or an expansible male member arranged to rotate inside a recess in the female. In the not unlikely event of uneven wear on the linings, the male member becomes eccentric, and when entered throws serious side strains on the bearings of the female. The need for ball-bearing thrusts, pivot pins, take-off springs and similar small parts adds to the complication and likelihood of trouble if neglected, as is almost always the case.

Friction drive may consist of a small pinion of iron, with surface grooved to marry with grooves in another iron wheel integral with the

winch drum, the smaller pinion being engine-driven by chain or spur gear wheel; or of a Ferodo, asbestos, horn, hide, paper, or cork and leather pinion similarly driven.

Whilst iron to iron gives a satisfactory coefficient of friction, it is not as popular as it was, which seems to show that it has objections. With a properly made cork pinion users are sure of smooth engagement with good resistance to wear, a life of five or six years being not uncommon.

Ferodo has a slightly better coefficient of friction. Cork frictions must be very strongly made to exert sufficient pressure on the laminations to avoid disintegration. Cork is sometimes interleaved with leather, but this does not seem to be more than a pandering to popular fancy.

The success of cork drive has long been established, whilst the fear of crumbling due to moisture is disproved by several instances of long accidental submersion under water and subsequent recovery undamaged.

Declutching is very simply carried out with a minimum of parts by mounting the winch drum axle in eccentric bearings, which can be partially rotated and so moved in a longitudinal direction by means of a short lever to which is attached a simple hand rope carried from the winch through a snatch block to a similar snatch block tied at the top of the scaffold. By this means the lever can be moved from any scaffold stage, thus giving complete control of the hoist.

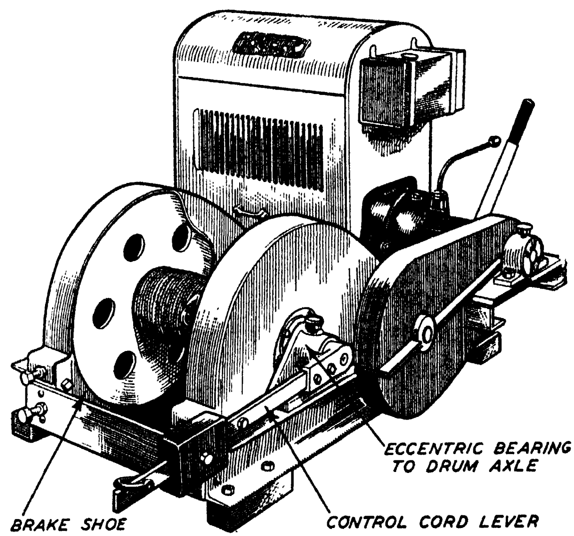


Fig. 9.—Typical example of a petrol-engine-driven winch for hoists

Pulling upwards on the lever moves the winch drum towards the engine-driven cork friction wheel, thus taking up the drive, whilst a counterweight on the lever serves to return the lever and drum away from the friction wheel and towards suitable Ferodo or wood brake blocks. Accidental release of the control cord through carelessness or illness thus applies the brakes automatically. In a good hoist the whole movement of the drum does not exceed ¼ in., thus giving extreme rapidity and certainty of hoist movement.

Safety Precautions on Large Hoists

Large hoists above 15 cwt. can be fitted with safety catches on the platform frame to avoid a fall in the event of the main rope breaking. In view of the high-quality rope generally fitted, this is a most unlikely occurrence, but when fitting a new rope to a hoist, which should be done as soon as one shows wear, a really good-quality rope must be chosen. It should be of steel wire, with the wires properly laid to prevent unravelling under load, and the diameter of the snatch wheel at the base of the hoist should always be stated, so that the suppliers can dispatch a rope of sufficient flexibility, a point which is often neglected.

The wear of a rope is determined by the rule that, if it shows more than 10 per cent. of broken wires in a length of eight diameters, it is unsafe. One end of the rope should be obtained seized, and the other end bent and seized to an eye, which is hooked to the platform frame if used single, or to the top of the mast or rail if used double, whilst the plain, seized end passes to the fastening clip on the winch drum.

The winch should never be placed nearer than 6 ft. from the base snatch wheel, as it would feed rope to the drum at such an angle as to give danger of overwinding instead of laying on coil against coil. If overwound, there is bound to be trouble through jerking as the platform is lowered and the coils slip back into place.

Specialised Hoisting Gear

In place of the usual flat wooden platform, hoists may be fitted with a tipping skip of a quarter- or half-yard capacity.

The skips being mounted on pivot pins or built with rack teeth to engage with curved racks, can be loaded, run up to the required staging level, and there tipped into a storage hopper of several yards' capacity, having a controlled outlet door through which the loads can be released into barrows, etc., as required.

In excavation work the hoist rails can be set up from the bottom of the pit and carried sufficiently high to allow of tipping into an improvised timber storage hopper arranged for discharge into the rubbish carts. With increase of capacity, these latter are becoming unfortunately much higher sided, with resultant difficulty in shovel loading.

Traversing Hoists

Another type of hoist allows a load to be raised vertically and traversed horizontally by the type of winch described in the preceding paragraphs, whilst preserving the advantages of one-man lever control. Unlike a crane, it can cover a very wide area without the need for a long space-demanding jib, the horizontal rails being standard, rolled-steel sections, easily suspended by clips from existing scaffolding.

It is of course impossible to give figures of working costs for any hoist,

unless the factor Amount of Use is known, but the following figures from an actual job may be of assistance:

Cost £180. Depreciation at 5-year life, plus interest, £22 10*s*. Repairs £2. Petrol £19 5*s*. Lubricating oil £3 6*s*. Driver £70 3*s*. 8*d*. Transport to and from job £1 16*s*. 6*d*. Erection 10*s*. Loads raised (mechanical counting register) 11,532 mixed concrete, bricks, roofing slates, etc., or a cost of approximately 2*d*. per load.

Real satisfaction will only be obtained from a hoist if strict account is kept of its performance. Any driver, given a slate and pencil, will take a pride in finding out how much his charge has done, and the writer has not the slightest doubt but that a hoist will prove to be one of the finest investments the modern builder can make.

Portable Cranes

In addition to the platform hoist, builders have recently been offered the choice of several small cranes which are particularly adapted for lifting through small distances.

The majority of them consist of a rectangular metal base about 4 ft. by 3 ft. suitably braced to sustain a king post or upright which may vary from 5 ft. to 7 ft. in height. Attached to this is a light jib arm, with a brace running to the lower end of the king post, the whole forming a short jib crane. On the rear end of the base is a metal engine house containing a water-cooled petrol engine and suitably driven winch.

The control is by lever from the front of the engine cover, allowing the operator to see the load throughout its travel.

And Their Uses

Fitted with a tipping gowk or bucket, they are seen to best advantage in excavation work for foundations, pipe lines, etc., and if fitted with an extension to the king post, as is easily done, they will raise a load, swing it over a hoarding, and dump it into tip carts at a speed far beyond any other appliance.

Cranes are usually considered to be beyond the requirements of the average builder, but they are so adaptable as to be almost a better investment than the platform hoist.

Their ability to swing full circle about the king post enables them to reach into the most inaccessible places, whilst their light weight, combined with the ease with which they can be stripped into several separate parts, allows of their being placed at the top of a building without the slightest danger to the structure or the need for extra bracing or supports.

Choosing a Crane

In choosing such a crane, the essential feature is stability, to remove the slightest risk of overturning. Provided that this is established by

an actual demonstration on rough ground, such as is usually met with, instead of a flat concrete floor which is the salesman's choice, none of the makes at present on the market has any weakness. With a well-made engine, repairs and petrol consumption are negligible, whilst its small size makes it easy to transport from job to job.

Chapter III

STEEL SCAFFOLDING

NO item of builders' plant has gained popularity so rapidly as tubular scaffolding, and its many advantages over the pole scaffold leave little room for doubting that it will soon entirely replace the latter.

Correctly used, it is more rapidly erected; less likely to deteriorate; more convenient for internal work owing to the wide range of lengths available in the standards; and, takes up far less valuable space when stored.

Why great Care is Necessary when Selecting Tubes

Although there are many varieties of fittings, they all serve similar purposes and are all used in conjunction with similar steel tubing. Whatever system is adopted great care should be taken in selecting the tube, as competition has led to the introduction of cheap grades which have numerous faults. As many fittings are inserted in the ends of the tubes, it is advisable that the bore should be uniform and as nearly circular as possible, and these features are not found in cheap tube.

Numbers of proprietary brands of fittings depend for their grip on the contact of a semicircular forging with the tube. If the latter is cheap, and ridged in the neighbourhood of the seam, contact takes place on a line and not on a surface, with resultant risk of slipping. Low-priced tubing, being of inferior metal, is also far weaker as a column, the position in which it has to withstand the maximum stresses.

Types of Tubing

Tubing can be purchased either painted, galvanised, or Sherardised, the galvanised probably being the best. As this adds about twopence per foot to the first cost of the tube it may be necessary to use the painted tube, but it will be equally necessary to repaint at least once a year if the scaffolds are not to look unsightly. Whilst it is too early to say that rust corrosion weakens the tube, it seems likely that it will.

Painting Tubes

There are several methods of painting the tubes, and all demand a thorough cleaning-off of rust and scale, this being easily done with a wire brush driven by an electric motor through a flexible shaft. The best type of wire brush to use is one that is cup-shaped.

The painting can be done by laying the tubes in lots of a dozen,

Fig. 1.—Steel scaffolding is an indispensable adjunct to modern building operations

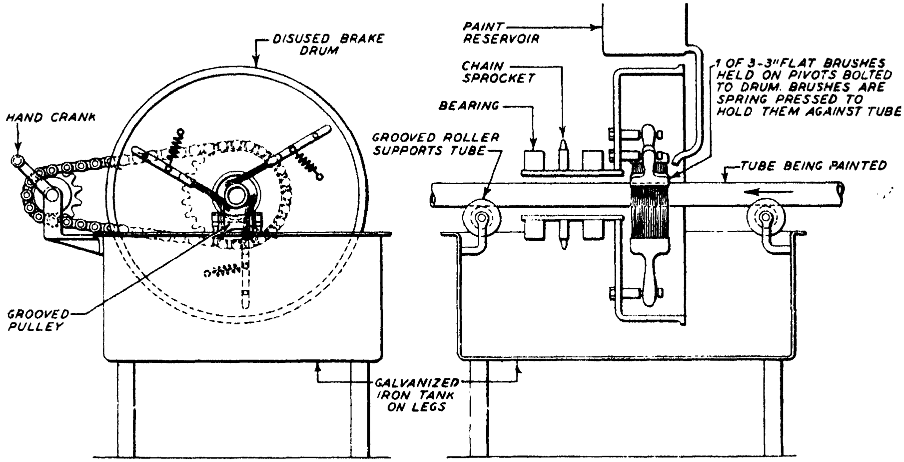


Fig. 2.—AN IMPROVISED MACHINE FOR PAINTING STEEL SCAFFOLD POLES

side by side on two horses, and flooding with a 4-in. flat brush ; by dipping in a paint reservoir made from a plugged length of 4-in. steam pipe sunk in the ground ; or by passing the tubes through a rotary head machine.

Vertical dipping needs a 17-ft. sunk pipe, an overhead block and light fall rope, and a quick-grip clamp, so that the wet tubes can be hauled out of the paint. It is wasteful and not so rapid as the machine method, which is used by the largest of the scaffolding firms.

The diagram (Fig. 2) shows a machine, improvised from spare motor parts, fitted with three spring-pressed brushes fed from a drip can, the motion being obtained from a fractional horse-power motor. If power is not available a hand crank will give good results if geared to give about twenty-five revolutions of the head per minute.

Whichever method is adopted it is a surprisingly long job ; for example, the tubes from one contract at a three-thousand-seat cinema cost £53 to paint when using paint at 10*s*. 6*d*. a gallon and labour at 1*s*. 3*d*. an hour. Despite care in handling, the tubes so painted soon lost most of their covering.

How to Store Tubes

Storage space is best formed by using the tubes and fittings of the system to form cellular racks, a suitable size having four standards 10 ft. long connected by four ledgers 16 ft. long at 6 in., 3 ft. 6 in., 6 ft., and 9 ft. 6 in. from the ground ; three of these sections cross-connected in a putlog manner by 16-ft. standards will give a rack capable of holding about 40,000 ft. of tube.

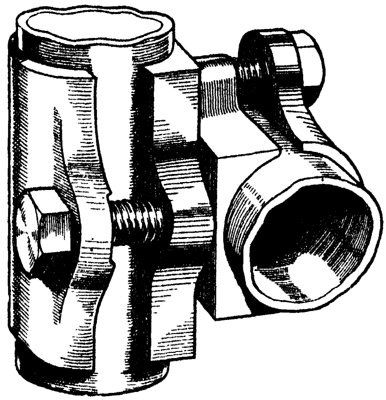


Fig. 3.—" Big Ben " single-bolt swivel

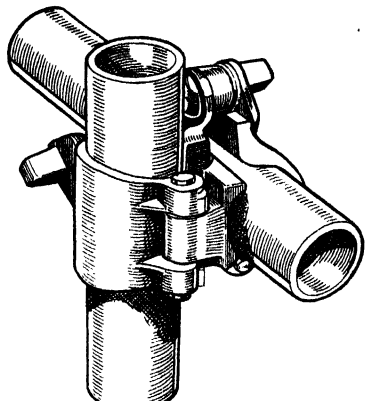


Fig. 4.—A camloc fitting
No slip up to 3·6 tons.

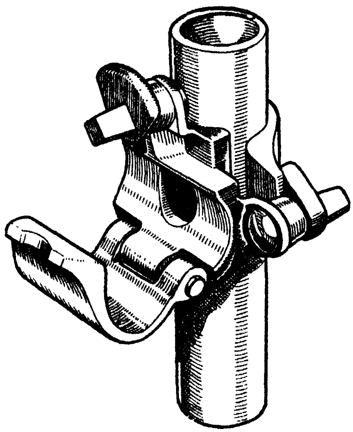


Fig. 5.—Camloc ledger coupling

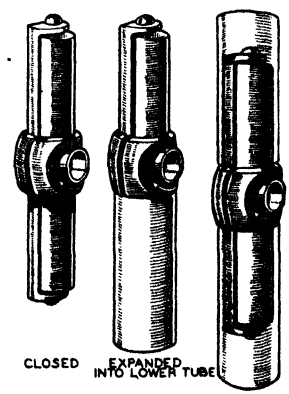


Fig. 6.—Internal-expanding type

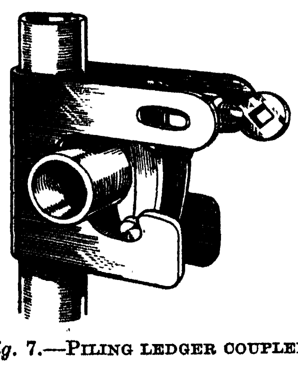


Fig. 7.—Piling ledger coupler

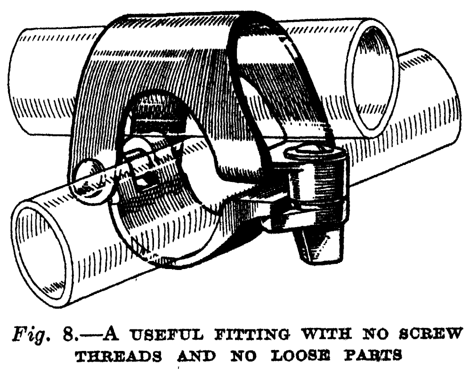


Fig. 8.—A useful fitting with no screw threads and no loose parts

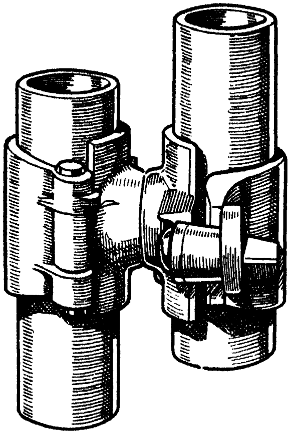


Fig. 9.—CAMLOC SWIVEL FOR DIAGONAL BRACES

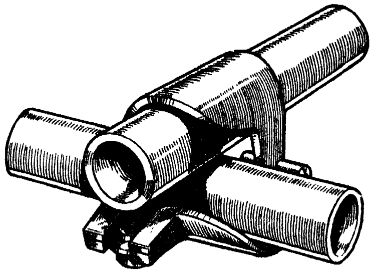


Fig. 10.—" BIG BEN " PUTLOG COUPLER

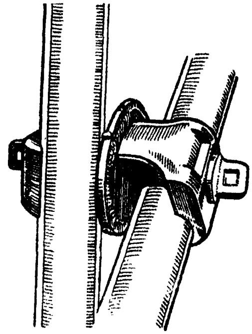


Fig. 11.—ANGLE COUPLER

For use in bracing from uprights and for handrails.

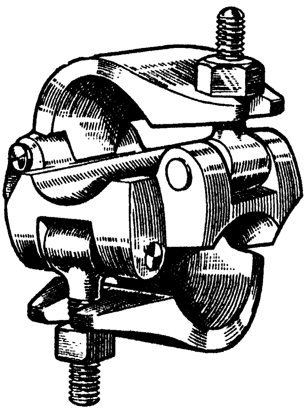


Fig. 12.—ONE-PIECE COUPLER

Useful for the ordinary cross-tie.

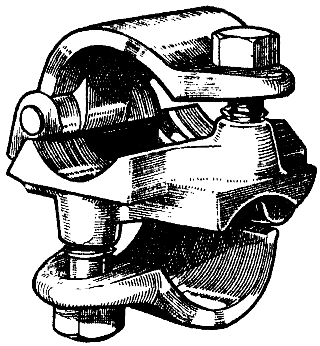


Fig. 13.—ANOTHER TYPE OF ONE-PIECE COUPLER

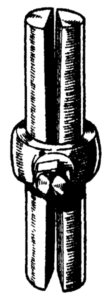


Fig. 14.—EXPANDING JOINT PIECE

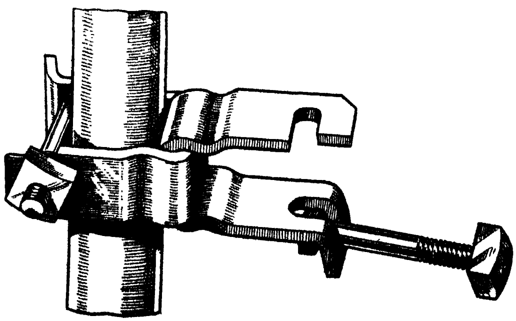


Fig. 15.—MILLS COUPLER

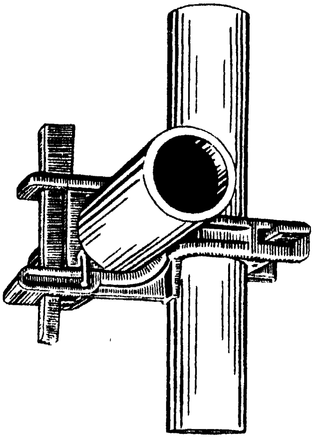


Fig. 16.—TWO-WEDGE COUPLER FOR FIXING LEDGERS TO STANDARDS

This rack should be under cover but arranged so that the lorries can be backed on to it so that the tubes can be slid in and out of the cells.

Causes of Tube Failure

Tubes fail usually from being strained out of line and so bent ; but they are too frequently used as arms for fixing gin wheels, with the same result. Attempts to straighten them are not likely to succeed unless they are put through a correctly-designed press, and the best method is to cut the damaged portion out and use the short ends for reveal work. Lengths of as low as 18 in. can be used as rungs for a ladder by clamping to two parallel standards about 1 ft. apart.

The Longest Lengths should be Sent Out First

Where a builder's stock of tube is comparatively small, it is advisable to send the longest lengths to a job on the early loads, as there is always a demand for the short lengths for interior work in the later stages of the average contract. All makers issue instructional pamphlets, and these should be given to scaffolders working with tubing for the first time, rather than to the general foreman; who is usually too busy to attend to such details. By this means a great tendency to be too liberal with braces and couplers will be avoided.

Fittings

These are made in a number of shapes to suit their several purposes, the principal ones being those that connect ledgers to standards ; those which connect putlogs to ledgers, and bracing or swivel fittings for diagonals. All are essentially clamping devices.

The ideal coupling should be strong ; have as few parts as possible ; as few loose parts as is compatible with simplicity, and lastly, require a minimum of maintenance.

Strength is assured by the use of drop-forgings. Malleable-iron castings come next in order of strength, with ordinary cast iron last. A multiplicity of parts always leads to loss of the smaller pieces, which by their size appear to be worth but little care. If the scaffolder has to carry a sack of mixed parts he will invariably lose time by blind groping in a sort of lucky dip.

Maintenance of Fittings

Maintenance can be kept to a minimum by choosing fittings which have as few threaded clamp screws as possible. In some makes it is necessary to drill and re-tap the threaded holes oversize at intervals to allow for wear, whilst the threaded portions always suffer from splashings of mortar and cement, which must be laboriously removed.

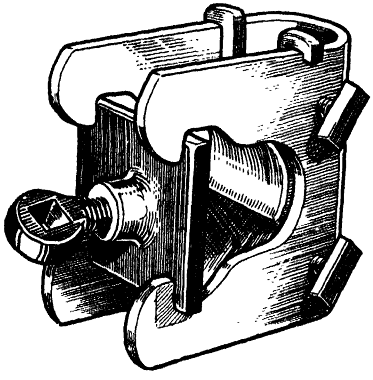


Fig. 17.—Three-piece coupler

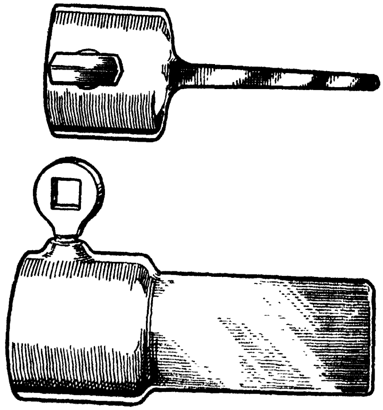
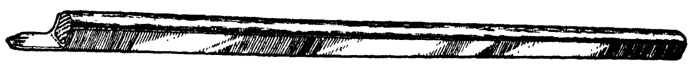


Fig. 18.—Putlog end for use with ordinary short tubes

Fig. 19 (*below*).—Tubular putlog



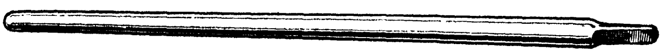


Fig. 20 (*above*).—"Channel" type putlog

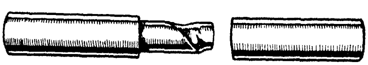


Fig. 21.—Worm spigot
For joining tubes end to end.

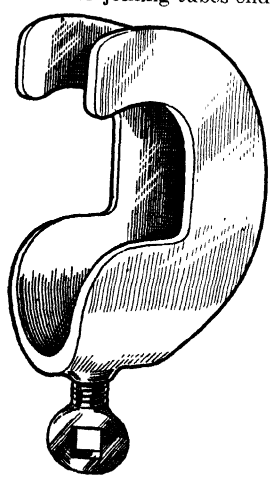


Fig. 22.—Coupler for fixing putlog to the ledger

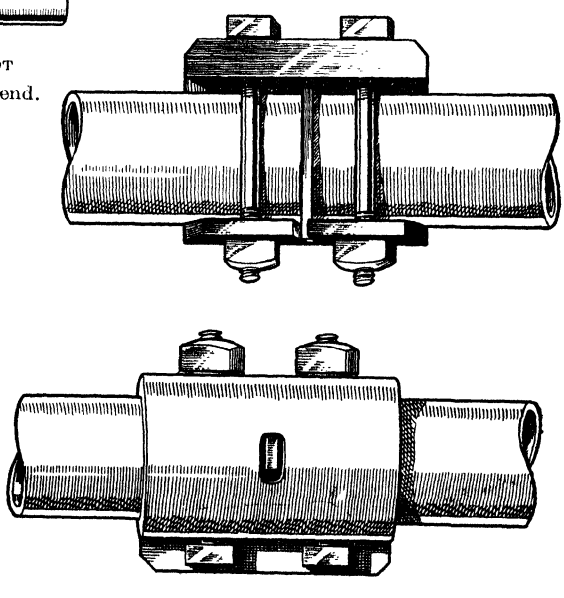


Fig. 23.—Mills end-to-end coupler

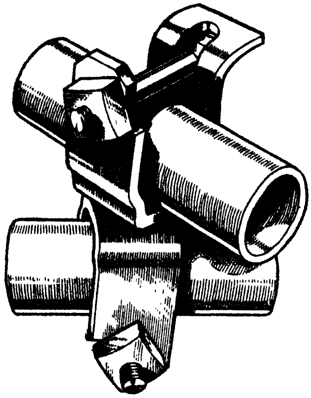


Fig. 24.—Mills swivel

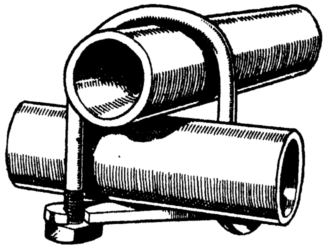
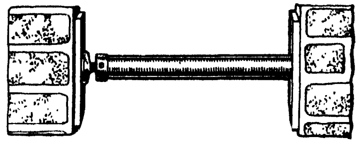


Fig. 25.—Mills putlog clip



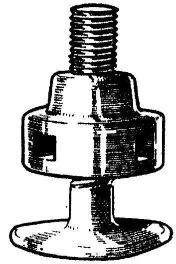


Fig. 26.—Adjustable reveal tie

For tying scaffolds to buildings in occupation where ties cannot be introduced into the room.

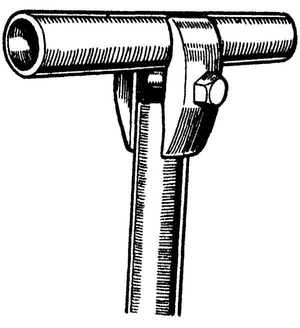


Fig. 27.—Finial clip

An excellent joint at the top members of gantries and stands.

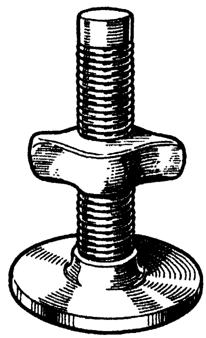


Fig. 28.—Adjustable base

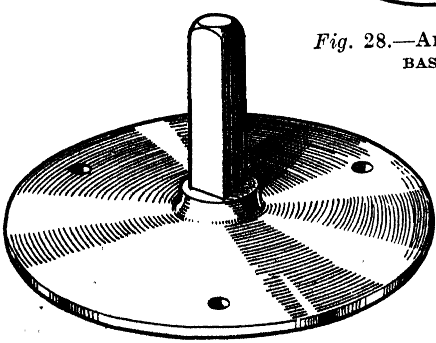
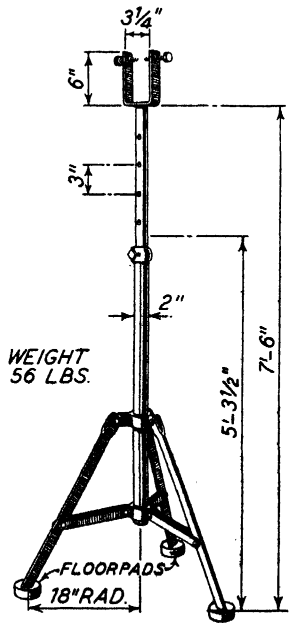


Fig. 29.—Base-plate



FLOOR PADS FOR THE PROTECTION OF POLISHED FLOORS, ETC., ARE FITTED FOR A SMALL CHARGE.

Fig. 30.—Plasterer's adjustable split-head

These seem to be small points, but the builder cannot afford to keep men at work rectifying faults which could have and have been avoided by careful design.

One make of fitting requires no other care than dipping in waste oil in a two-compartment tank, transfer to the second compartment for draining, and final storage in bins. That this oiling tends to spoil the frictional grip of the fittings when in use is disproved by experience in oil-field work, where general greasiness of machinery and plant is common.

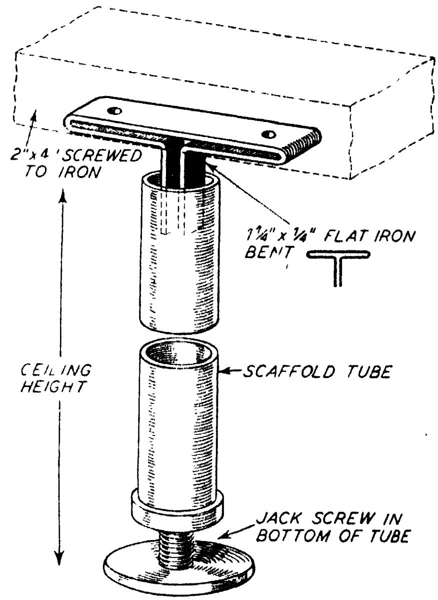


Fig. 31.—EXTEMPORISED HEAD-TREE

Load-carrying Capacities can be Disregarded

Salesmen often quote figures to show the load-carrying capacity of their fittings, these loads varying from 1½ to 4 tons with different makes. As these loads are far in excess of anything likely to be carried by an ordinary scaffolder even under severe conditions, and as built-out scaffolds would certainly be reinforced by suitable braces and struts, the figures may be disregarded.

Much is made of relative lightness, but the proportion of weight of fittings to tube is such that it has little bearing on transport charges and only becomes important in the erection of towers. We would refer to a fitting designed for this work which, by incorporating three fittings in one, saves a great deal of weight, but it is hardly within the usual requirements of the medium-grade builder.

Reference to the illustrations shows that some systems have fittings capable of a variety of uses, whilst other systems require different fittings for each purpose. This universality is not always achieved without sacrificing simplicity, and it is questionable whether it is an economy to employ a fitting capable of doing an important part of

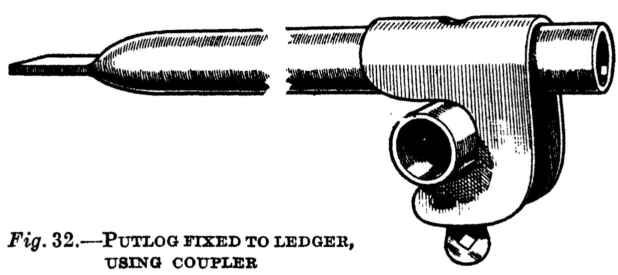


Fig. 32.—PUTLOG FIXED TO LEDGER, USING COUPLER

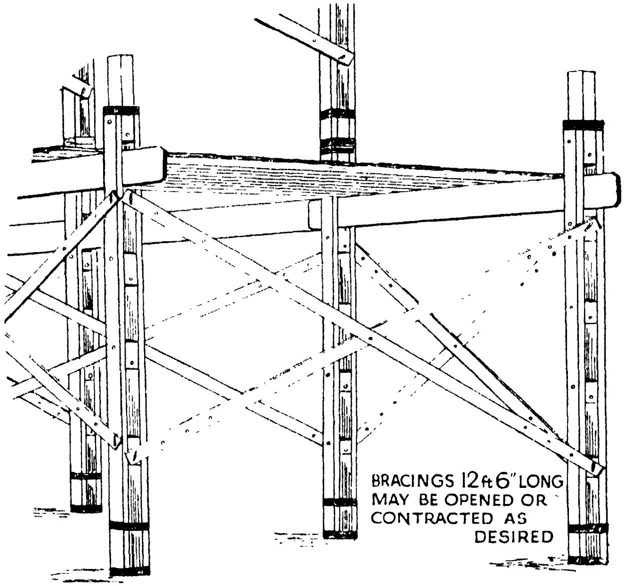


Fig. 33.—" RAP-RIG " SCAFFOLDING

the work by using it for some simpler job which could be carried out by a different and cheaper fitting. Any ledger coupling will serve as a putlog clip, but all systems have the two as separate designs.

Other Uses of Tubular Scaffolding

Tubular scaffolding can be used for several purposes. By means of small screw jacks inserted in the tubes they may be used for the support of shuttering in place of the more expensive roof shore. Pieces of flat iron bent as shown (Fig. 31), when screwed to lengths of 2-in. by 3-in. or 2-in. by 4-in. deal, form efficient head trees ; or finial clips can be purchased which will carry short tubes as horizontals.

Saving of Putlog Holes

One of the advantages of steel scaffolding is claimed to be the saving of putlog holes in the brickwork. This is true in some cases, but there are putlogs with such thick ends that they cannot be retained in the joints of the brickwork when the mortar joints are specified ¼ in.

Tying-in of the Scaffold

The tying-in of the scaffold by means of reveal screws inserted in short lengths of tube can be a dangerous process when soft facings are used, and it is preferable to use some form of internal fastening at intervals to guard against spalling of the bricks and loss of grip.

Base-plates

Except in special circumstances there does not seem to be much need to purchase the base-plates which are listed by most systems,

a 2-in. by 9-in. deal forming a satisfactory bed and allowing the tube standards to bite their way into a stable position. Where base-plates are used care must be taken that the standard is not canted when withdrawing it from the upright peg, as some of the latter, being badly butt-welded, tend to snap off at the weld.

Steel Scaffolding used for Interior Decorating

Interior decorating of ceilings, cornices, and the like can be conveniently carried out by the use of a movable tower made from four standards with suitable cross-bracing, each standard being fitted with a castor wheel. By using two towers with a connecting bridge the writer was able to employ twelve painters working alongside one another and to complete in one night a job which formerly took three.

Some Interesting Conclusions

A recent inspection of a number of scaffolds erected in tube with different systems of fittings leads to the following conclusions as regards steel. Users are inclined to overdo standards ; too many fittings are carelessly fastened, a fault rarely seen on pole scaffolds with either chains and roses or wires ; guard boards, except in the case of the largest contractors, were conspicuous by their absence, despite the fact that bent iron clips to hold them in position are the cheapest of the fittings ; guard rails were in some cases entirely absent.

There is no need to waste time over commiserating with the uneconomic use of tube, but there are no words strong enough to condemn a builder who with the fullest knowledge of the dangers involved exposes his workers to risk of injury, nor is it possible to forget that the whole of the scaffolds in question were in prominent positions and readily seen by Home Office inspectors.

In purchasing steel scaffolding buy the best it is possible to afford, and if the cost of erection on its first job be carefully checked and compared with the cost of using poles, it will be seen to be a worth-while investment.

Scaffolding for Interiors

A form of scaffolding in which the vertical members are built of light quarterings, separated at intervals by blocks with bolts passing through the whole, is illustrated, because it is more rapidly erected than any other system and, being of timber, is more suited to use in the interior of buildings such as churches, museums, shops, and theatres, where accidental dropping of a steel tube might cause irreparable damage.

The only loose fitting is a butterfly nut which serves to clamp flat diagonal timber braces to the standards. Scaffold boards set on edge

serve as ledgers, and where extra strength is needed special standards can be obtained which allow of the use of two scaffold boards side by side.

The cost of the system is lower than any of the steel-tube ones by about 40 per cent., and the weight is about 50 per cent. less when the correct proportion of fittings in steel systems is allowed for.

If painted, a life of ten years is to be reasonably expected, but it obviously takes up more room in storage than tube and cannot be expected to have the strength of the latter. With these limitations, it can be said to fill a useful gap between poles and tube.

Chapter IV

SMALL TOOLS FOR THE BUILDER

DESPITE their many advantages, the labour-saving tools introduced to the building trade in such variety in the last few years can be a serious disappointment unless care is taken both in buying and using.

Fully occupied with the details of his craft, the builder is not too well equipped to decide the merits of the electrical and pneumatic appliances offered to him by enthusiastic salesmen. The object of this chapter is to point out the likely troubles that will be met in practice and the best methods to adopt to keep down repair costs.

Wheelbarrows

Such an apparently simple article as a pneumatic-tyred wheelbarrow can be as full of faults as a horse. Competition has led as usual to price cutting, with the result that quality has suffered.

The tyres themselves are beyond reproach, being the product of long-established firms, but when commencing to form a fleet of barrows, it is advisable to decide on one make of inner tube and one particular size of valve. They can and do vary, so that it is necessary to have a car, a motor-cycle, and a bicycle pump to inflate them. The smallest size is preferable, as a pump can then be kept on each job using the barrows, the low air pressure required being easily sustained. Cast-iron spoked wheels suffer from fractures of the spokes, probably due to contraction in manufacture, and the central hole, being cored, is inaccurate so that the axles wobble. The best method of getting over this trouble is to drill out to 1 in. diameter, fit inch mild-steel shaft, and replace the inadequate set screws by new ones $\frac{3}{8}$ in. in diameter. If this is not done, the men in their attempts to secure the axles will twist the heads off the screws.

In purchasing wheels to replace existing iron ones, be quite sure that there is clearance between the tyre and the sloping front of the barrow. If not the body will be rectified by hammering, which will spoil the tipping.

The valves are usually protected by a short piece of rubber tubing slipped over the ends. This should be further protected by a piece of $\frac{1}{2}$-in. hose about 4 in. long slipped over the smaller tube and wired to a spoke.

Should the valve be wrenched off, as often happens when they are not properly protected from cement, new valves can be inserted by stretching the valve hole in the inner tube.

A desire for more work from his labour often leads a builder to decide on barrows of 4 cu. ft. capacity, but some tests made recently show that they actually reduce the output. Possibly it is a psychological reaction, but 4 ft. look too much and is too much for a man to wheel through a day.

Portable Tools

The greatest savings in labour have been accomplished by portable drills, hammers, and the like.

The introduction of portable tools for the cutting, drilling, and breaking which form so large a part of the builder's work has opened up a large field for the inventor. The inevitable result is that many devices are put on the market whilst in an incomplete form, the improvements being made in course of time as a result of the users' complaints. In other words, the user stands the expense of experiments.

This expense can be largely avoided by exercising care in purchasing, by buying only from established firms, by demanding a thorough demonstration, and by asking for the names of other users, some of whom will be well enough known to the inquirer to be approachable for opinions as to the merits of the tool.

Electrically-driven Tools

The first problem is to decide whether to use pneumatic or electrically driven tools. We will suppose that the reader is intending to buy one or more electrical tools, the use of which bringing with them the question of current supply. Although many jobs are or can readily be connected with the local mains, the charges for current are apt to be high, whilst the installation of a meter, with the fuse boxes, switches, and cables, by competent electricians runs into a great deal of money.

The next difficulty is that though the Grid system is making rapid headway, it is not yet universal, so that with most electric tools being fitted with motors to run at between 200 and 240 volts, there is always the possibility of being faced with a direct low-voltage supply of current, which is, of course, not capable of being transformed to a higher voltage as is an alternating supply.

In London alone there are nearly a dozen different voltages in use, so that added to the risk of some jobs having no current available, it is as well to commence by purchasing a small generator or, if cost is a consideration, having one made up in one's own workshop.

Electric Generator Sets

With ready-built machines portability is the first consideration, and many types are available at prices ranging from fifty to one hundred pounds.

As is the case with the home-made outfit, it is necessary to calculate

what size will be required, and for this purpose recourse must be had to the catalogue of the tool or tools to be used.

As an example, suppose two hammers are to be run with six 60-watt electric lamps. The hammers are described as taking 4 amperes each at 220 volts. Multiplying volts by amps. we get watts, in this case 880 for one hammer, or 1,760 for the two. Six lamps at 60 watts will take another 360, giving a grand total of 2,120 watts.

Dividing by 746, the number of watts in a horse-power, we find we want around 3 horse-power, or if we want the electrical power we divide by 1,000 to get the kilowatts demand. Ready-built sets of engine and generator are usually described as having an output of so many kilowatts, so that in this case, allowing a small margin, to be on the safe side, we should buy a 3-kilowatt outfit.

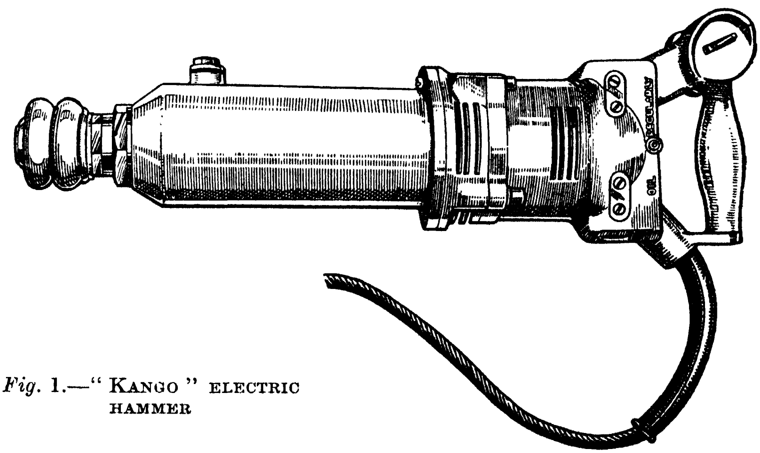


Fig. 1.—" KANGO " ELECTRIC HAMMER

Assembling Generator Set

In assembling a set, as most builders have on hand a variety of engines as used for hoists, crushers, etc., a little care is necessary to get good results. Although all electric tools have universal motors, that is, ones which will run equally well on alternating current or on direct, it is not advisable to purchase an alternating-current generator however tempting the price. A 2-kilowatt generator can be had for as little as £5, but unless the engine runs at a perfectly regular speed, that is, without fluctuating more than, say, 3 per cent., the current will not be produced at an even frequency, with the result that the power output will be extremely variable. The only safe choice is a small high-speed direct-current dynamo, guaranteed by the supplier to be self-exciting. If it is not good in this respect it may fail to give any current at all when started up.

Speed of Running

The next point concerns the speed at which it runs. This will probably be in the nature of 1,200 revolutions a minute. If, for example, an engine of 5 horse-power is to be used, and it runs at perhaps 700 r.p.m., it will be necessary to gear the engine up to the dynamo. This means that we can expect only half the horse-power at the other end of the belt, so that instead of 5 by 746 watts output we shall get seven-twelfths of 3,730 watts or 2,177 watts. In this case the engine will be powerful enough, but had we chosen a 3-horse-power engine running at 770 it would not do the job.

Belt Drive

The connection between engine and dynamo can be best made by means of one of the new endless V-belts which need not be run tight to get a drive, even if the engine and dynamo are set close together.

Completing the Generator Set

A double-pole switch, a double fuse board, and, if desired, a cheap voltmeter will complete the set, which can be mounted on a channel-steel frame with or without wheels.

Maintenance of Plant

The likeliest place for trouble on such a set is the commutator and brush gear. The former becomes blackened after considerable use, but can be cleaned by holding 00 glasspaper fitted to a curved piece of wood on to the commutator.

Dynamos are apt to and indeed must warm up when run for any length of time, but as long as the hand can be borne on the outside of the windings there is no need to shut down for a cool-off.

Regular lubrication of the dynamo shaft is of course essential, and from time to time the whole machine should be freed from dust, which is apt to collect in odd corners such as between the segments of the commutator.

Should the commutator become grooved or pitted it is not a difficult matter to remove it, when it can be trued in a lathe.

These remarks apply equally to the armatures of all motor-driven tools, neglect being soon apparent by reason of the heavy sparking at the brushes.

PRECAUTIONS TO BE TAKEN WITH ELECTRIC TOOLS

Although the average small tool running at 200 to 240 volts takes only around 5 amperes even under full load, operators can receive dangerous if not fatal shocks unless care is taken to install a suitable earth return from every machine.

In most cases electric tools are supplied with three-core cables

containing one red, one white, and one black inner lead, the red being the earth, but, the leads being necessarily short, extensions are nearly always fitted by the workmen, and the earth omitted, particularly when connecting to an electric-light socket.

The safe rule is to fit a three-pin plug on the end of every tool lead, and to have corresponding sockets fitted to other lengths of three-core cable, the final electric lamp-plug having the black and white connected and the red brought out for connection to a convenient water pipe or stanchion.

When two or more machines are in use, hanging multi-point connectors can be installed by an electrician, so that connection can be made by the mere insertion of the tool lead-plug.

A Suitable Warning Notice

The writer has the following notice affixed to the carrying boxes of all electric tools, and has so far had no accidents :

WARNING. THIS MEANS YOU

Electricity like water can escape through a leak. You can give it an easier path than through your body by providing a wire through which it can run to earth. Do not start this machine until you have made sure you are using a three-pin plug on a properly earthed three-pin socket. Ask the foreman to find out for you if you can't find out yourself. If there is no three-pin socket run an earth wire from the machine to the nearest water pipe, iron railing, or stanchion.

In the event of a man getting a shock, cover the burns with lint and lay him down in a quiet place covered with a coat or rug. Do not give stimulants.

Wiring should be done with elephant cable in which the leads are enclosed in a flat-section rubber covering, using the size known as 7/036 or 7/044 if it is twin, or 3/036 if it is triple. The latter is strongly advised.

All tool leads should be hung on hooks in the wall, but if this is not possible a protecting run of timber should be laid for the passage of wheelbarrows. There have been several fatalities through neglect of this precaution, owing to cutting of the rubber covering by the iron wheel.

DRILLING AND CUTTING TOOLS

Drilling

The simplest tool for the drilling of large quantities of holes in brick walls is the hand-operated spring hammer, in which rotation of two handles alternately lifts and releases a hammer against the action of a spring. The bits are hollow to allow of escape of the core, and suffer

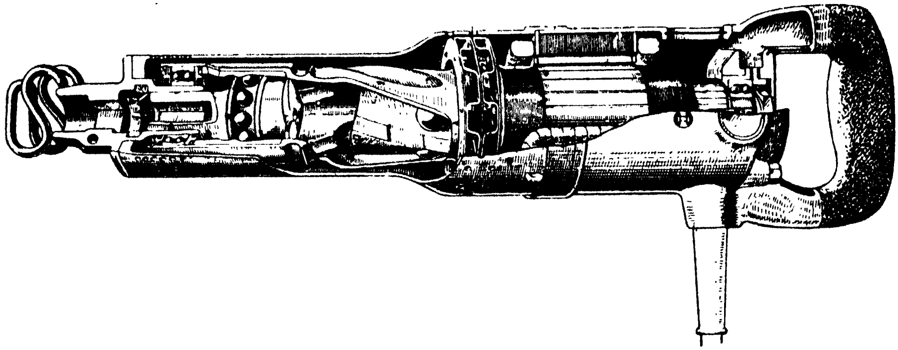


Fig. 2.—The C.A.V. electric hammer

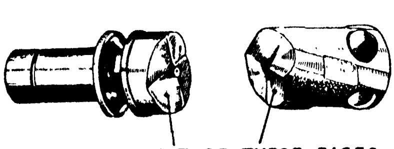


Fig. 3.—Striker parts of C.A.V. hammer

from only one disadvantage, which is their length. This hammer must not be confused with the small one used for Rawlplugging, as it costs around £7, and is naturally larger and capable of heavier work.

It will drill a 1-in. hole with 6-in. penetration in stock bricks in half a minute, or with smaller drills at correspondingly greater speeds.

Cutting of door openings in brick can also be speeded up with this tool by drilling a row of holes at the desired line, leaving the bulk to be cut with hand chisels.

Until recently there were no small tools capable of cutting and drilling except such as were driven by compressed air, which, although a convenient and economical method, suffers from a cost complex due to the natural association of it with the devastating road breaker or pom-pom.

As will be seen in this chapter, this difficulty has been overcome, and many builders will prefer to make use of electrically operated tools, as the first cost is so much lower.

The Electric Percussion Hammer

The essential feature of electric percussion tools being rapidity of the blows, the most attractive design consists in a solenoid machine in which a coil of insulated wire forms a magnetic field, which attracts a jumper against the action of a spring. Unfortunately the windings in this design of tool become very heated, and the usual hammer contains a ruggedly built electric motor whose rotary motion is converted into a reciprocating one by some patented mechanism.

Fig. 2 shows a C.A.V. motor-type hammer. This operates through the medium of a striking-block carrying four large steel balls in recesses

in its outer cylindrical face. These balls, which protrude slightly from the recesses, engage with helical grooves cut in the recessed end of the armature shaft. As the latter rotates it throws the striker forward, causing it to impart a blow to an anvil piece, which in turn passes the blow to the end of the chisel or drill. To achieve turning of the drill so as to avoid jamming, the anvil is shaped as shown in the sketch, the impact of the two inclined faces giving a twist to the rotatable anvil. The rebound of the striker carries the balls back into the armature shaft grooves, and the action is repeated.

It is obvious that such a mechanism must be of high-grade steel, and that it must be regularly lubricated if excessive wear is to be avoided.

Operation and Maintenance of Percussion Hammer

The makers advocate regreasing every 100 hours, and it is not unfair to assume that a new anvil will be required every 400 hours. Wear on the impact faces can be much reduced by seeing that the hammer is kept pressed to its job so that the force of the blow between tool shoulder and hammer body inside the spring tool-holder clip is kept at a minimum.

So successful are these hammers that they are always overworked, being used on material which would daunt their larger brother the pom-pom. This results in blunted tools and reduced output.

It is advisable to purchase a duplicate set of tools, so that the delay can thus be reduced to a minimum, although the sharpening is done very quickly by the English agents.

Paying an extra penny an hour to the operator, the total running cost, including writing off first cost in two years, has worked out at 2*s.* an hour. If the user does his own regreasing and tool sharpening this figure will be reduced to 1*s.* 10*d.*, but even the higher figure is extremely small in comparison with the amount of work the hammer will do.

It must be borne in mind that every 400 hours' work may entail a spare-parts bill for six or seven pounds, but this figure can be lowered by careful handling, particularly by avoiding idling by the operator who is apt to put so little pressure on the tool that the major part of the blow is taken up by the mechanism instead of being absorbed at the cutting end.

There is another type of hammer, in which a different mechanism is adopted to convert the motor revolutions to blows, the makers claiming longer life to the parts ; whilst yet another is marketed which converts by the use of an intermediate air piston.

In buying a hammer it is as well to remember that rapidity of blow is the essential requirement, whilst demonstrations should be of as extended a nature as possible and on the actual material to be handled.

Performance

Channelling in brick should be done at about 3 ft. a minute, whilst the penetration in good-quality concrete should be about 4 in. a minute for a $1\frac{1}{8}$-in. diameter hole.

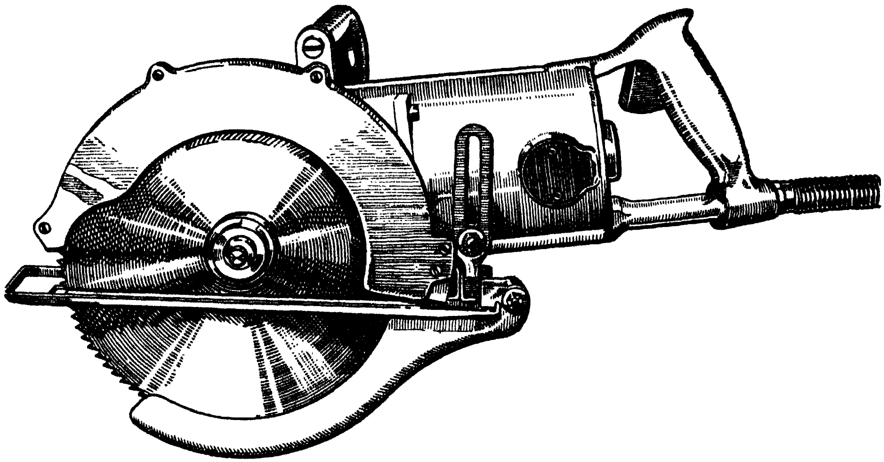


Fig. 4.—Electric saw tool

The weakest point in electric hammers is the actual tool, which, being kept small so as to come within the capacity of the motor, is unable at present to show a long life. In purchasing, it is well to satisfy oneself that tool replacements can be readily obtained. The hammer being a percussion tool, there are times when the shattering effect is a disadvantage, and it is an advantage to use an ordinary electric drilling machine with a special bit.

Electric Drills

Drills can now be bought tipped with Wimet steel, which will handle the hardest materials, and for plugging in soft brick are preferable to any other method. Care is necessary so that the tip should not be stripped from its lower-grade body, and it must be remembered that the tips cannot be sharpened on ordinary wheels. With these qualifications they have everything to recommend them.

Cutting Tools

The introduction of steel-centred discs coated with a ring of aloxite carborundum or other abrasives has led to the use of electric-motor-driven machines for the shaping of bricks, tiles, and similar hard substances, the speed and accuracy of the work being many times greater than by hand, but a satisfactory substitute can be built from a grinder head belt-driven from a mixer engine.

A rough wood stand provides all that is needed, the high speed necessary being obtained by running the belt from the flywheel rim and not from the pulley of the engine.

For builders who require something more elaborate there is a wide

choice of electric drills, which can be fitted with discs or saws in any variety to suit material, whilst there is now available a choice of electric saws specially made for use in the hand, which allows them to be taken to the work.

The illustration shows an electric saw, the under-side guide being movable to any angle so that bevels of any angle can be repeated at will.

Operating Cutting Tools

When cutting vitreous material, it is necessary to avoid any side movement of the cutting disc, which is extremely brittle. An extemporised slide built of angle iron supported on a bench will allow the saw to be moved along in a straight line, whilst the brick or pipe being cut is held rigidly beneath it in a wood rest. Water should be supplied as a lubricant, and in the event of there being no pressure supply a tank set on a convenient staging a few feet above the machine will answer the purpose.

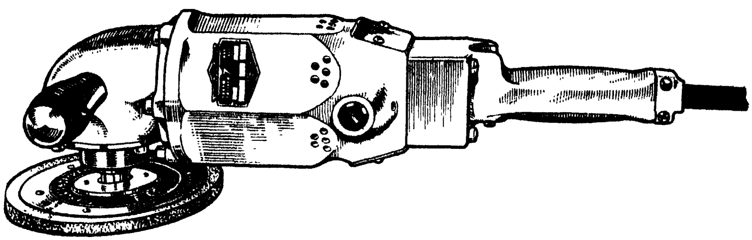


Fig. 5.—Hand electric surfacer

The cutting of timber within the limits of these electric saws presents no difficulties unless the saws be allowed to get blunt. If they are, the motor will become overheated or burnt out, necessitating a rewind, costing three or four pounds. Once again it pays to have two sets of saws, so that sharp ones are always to hand.

Made in various sizes, the most useful is one which will clean cut brick thickness, despite the extra weight involved and the slightly higher cost. Once again, there is no question of the enormous economies gained by their use.

Abrasive discs can be used for the cutting of steel reinforcing rods, but it is not an economical process over ¾-in. diameter, and up to that size a good bolt cropper is quite satisfactory and quicker.

Oxy-acetylene Metal Cutter

When it comes to cutting larger sections there is no doubt that the oxy-acetylene cutter is the best tool, particularly as it is of such frequent use in the cutting of steel sections. There are several makes of cutting-torches on the market, but there would seem to be little to gain from

buying except from the suppliers of the compressed gases, particularly as their servicing arrangements are country-wide.

A cutter taking up to 6-in. metal is large enough for most builders' purposes, and will enable quite heavy cast-iron sections to be blown away. The operator should be forced to use goggles, but the provision of gauntlets is apt to be a waste of money.

One warning. Under no circumstances should galvanised iron be cut with the flame. The fumes are definitely injurious.

Oxy-acetylene Cylinders

When ordering cylinders it is better to choose the small sizes, of 100 cu. ft., than the larger ones, which are too heavy to be easily moved. A sack barrow with rubber-tyred wheels can be easily adapted to carry an acetylene and an oxygen cylinder, and a tray or box fitted at the back for the holding of the torch and hose. Do not buy any torch which has internally tapered nozzles. The solid type can be filed back as it burns away, still presenting a smooth-sided annular opening, whilst the others are immediately rendered useless.

With a little practice the burner can be used for the cutting of bolt holes in erected steelwork. There is no basis for the idea that the heat reduces the tensile strength of the steel, as it is quite local in its effect.

GRINDING AND SURFACING

These operations can be carried out with discs faced with abrasives, and revolved direct on the spindle of a small electric motor or through the agency of a flexible shaft.

The former method has the advantage of lightness with a flexibility which allows of getting into awkward corners, but the latter allows of the use of a larger and therefore sturdier motor.

Flexible shafts unfortunately will not stand kinking, a misfortune which is only too apt to occur in building work, so a type should be chosen

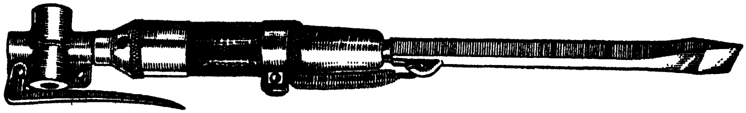


Fig. 6.—PNEUMATIC PAINT-SCALING TOOL

which has as strong an outer casing as possible. Frequent lubrication is essential, and the greatest care must be taken to avoid the inner cable getting wet. Considerable friction is developed between this inner cable, which is in form a spiral of piano-steel wires, and the outer case, with

the result that neglect causes the wires to become heated, to lose their temper, and finally to unravel.

Another cause of disappointment can be the excessive wear of the discs, which are not particularly cheap. This is mostly due to too much pressure, but frequently due to surfacing being confused with the actual cutting away of surplus material.

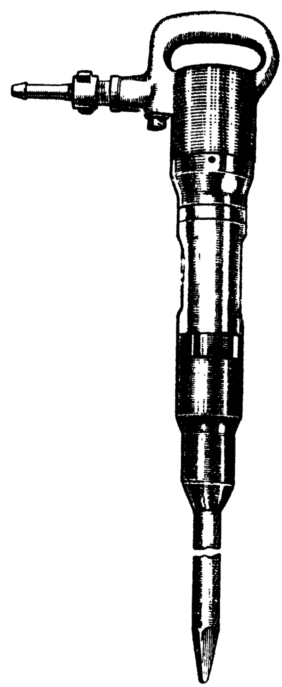


Fig. 7.—Pneumatic light concrete breaker

COMPRESSED-AIR TOOLS

There is a grave possibility that regulations will be made forbidding the use of electricity at voltages above 35 or 40, so that small tools of around 1 horse-power will have to be run at amperages of 40 or 50, which will lead in turn to such an increase in the size of supply cables and motors as to place electricity out of court for general building work.

Although compressed air is admittedly more expensive to produce, it has many advantages. The tools are rugged and little prone to wear or breakages; they can be operated by even less-skilled labour; air can be piped to any part of a job in low-priced barrel; there is no possibility of danger to the users; and finally, there is a far greater reserve of power for emergencies.

Fig. 8.—Sheeting driver driven by compressed air

Compressors can be bought and mounted to a builder's own engine, or there is a wide choice of suitable sets, either Diesel-engined, with resultant economy in fuel costs, or petrol-engined for those with a prejudice in favour of the better-known mechanism.

All pipe lines from compressors should be fitted with a trap. The only care needed with the tools is to blow a charge of oil through them after a day's work.

Chapter V

CONCRETE MIXERS AND MIXING

THE cost of mixing concrete by hand being in the nature of five to six shillings the cubic yard as compared to, say, a shilling by machine, it is not surprising that the latter method is so rapidly replacing hand mixing. In addition to its economy the machine is able to produce better quality and more uniform mixes. Ranging in size from miniature affairs mounted on a wheelbarrow to gigantic batching plants capable of producing several hundreds of cubic yards in a working day, most mixers are described in terms of their input of dry material and their output of mixed concrete per batch, the only exceptions being the few so-called continuous mixers.

As an example a popular size is the 7/5, which takes a charge of 7 cu. ft. of aggregate and cement and delivers 5 cu. ft. of wet concrete at each batch. Similarly, a 5/3½ takes a load of 5 cu. ft. and delivers 3½ cu. ft. of wet concrete.

Types of Mixers

Mixers may be roughly classified as either roller pan, tilting drum, closed drum, batching plant, or continuous machines, but for ordinary requirements the tilting- or the closed-drum type is preferred.

The Tilting Drum (Open Type)

This consists of a roughly conical drum open at its smaller end and arranged to turn about a vertical axle pin carried by a yoke which is suspended in trunnion bearings so that the drum, being provided with a toothed ring around its base, can be rotated by an engine-driven bevel pinion carried on a shaft protruding through one of the trunnion bearings.

Being tilted by a convenient handle the yoke, axis pin, and drum can be inclined at any angle about the vertical without the drum having to be brought to a standstill. Inclined to around 60° from the vertical the drum presents its open mouth to the operator, who can then throw a charge of ballast, sand, and cement into it. Suitable paddles in the interior of the drum stir the contents, and the addition of water allows of the mixing of the concrete, whilst inclination of the yoke, pin, and drum away from the operator allows the drum to tip its contents into a wheelbarrow.

Constructional reasons allow these mixers to be sold more cheaply than the closed-drum type, but they are not usually seen in larger sizes than 7/5. The loading by shovel is necessarily slow so the larger sizes

are fitted in this size with a mechanically operated loading hopper which lifts the charge to such a height that it can run into the drum by gravity. As this form of loading is common to closed-drum mixers, which are usually considered to mix better than the tilting-drum, there would seem to be little advantage in using tilting-drum mixers above hand-loading size, and the 5/3½ is in consequence the most popular.

Unrivalled for Mixing Mortar

The 5/3½ tilting-drum mixer renders its best service in the mixing of mortar, and for this purpose it is unrivalled. It also has the advantage of low over-all height, so that it can be used between the floors of buildings, is narrow enough to be taken through interior doorways, and by a simple process of dismantling into three parts can be readily lifted on to a flat roof, where it can be reassembled for use.

Daily Output of 5/3½ Mixer

It would be unfair to expect a large output from these machines, which cost on the average only one-quarter as much as a 7/5; but any builder doing work large enough to need one of the latter can find good use for a 5/3½, and if it is carefully handled can expect an output of 15 cu. yd. per day of mixed concrete from two men.

Closed-drum Mixers

In the closed-drum mixer, of which several makes are illustrated, the drum is a narrow cylinder of about 3 ft. in diameter and 2 ft. in width, fitted at each end with a cup-shaped plate having an aperture of approximately 1 ft. 3 in. diameter.

The drum, which may be of ⅜-in. steel plate or in some cases of a steel casting, is provided with two substantially flat tyre bands which rest on four rollers carried by the frame of the machine so as to provide easy turning of the drum about a horizontal axis.

Pivoted to the frame, on a line near the centre of the aperture in one of the endplates of the drum, is a loading hopper which,

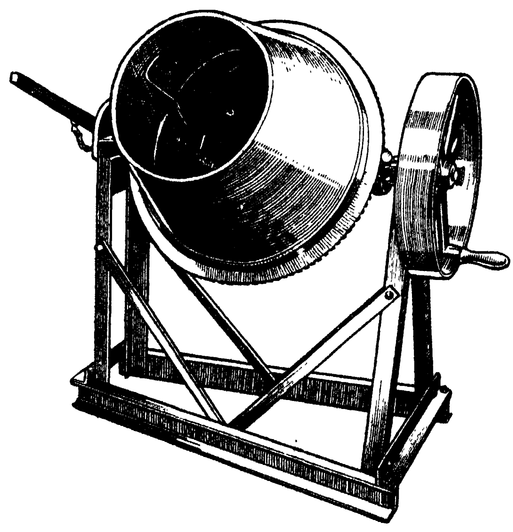


Fig. 1.—HAND-WHEEL CONCRETE MIXER, 50 R.P.M.
This type of mixer has an output of 1½ cu. ft. of wet concrete at each batch.

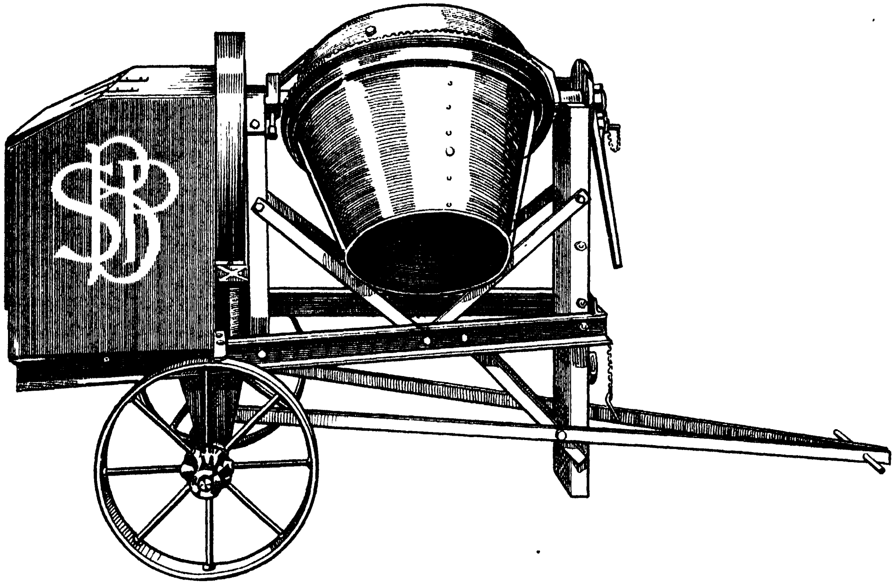


Fig. 2.—A SMALL PETROL-DRIVEN CONCRETE MIXER

This mixer has an output of 3½ cu. ft. of wet concrete at each batch for 5 cu. ft. of aggregate and cement.

by means of wire ropes wound around drums driven by the engine of the machine, can be raised to a vertical or nearly vertical position. This allows the aggregate and cement to fall by gravity into the drum. The latter is provided with paddles fixed to the cylindrical portion in such a way as to carry the material up inside the drum, allowing it to cascade and fall to the bottom at every revolution. On the other side of the drum a hinged chute is arranged which when swung inwards catches the wet concrete in its fall and allows it to slide down the chute and so out to the barrow or skip waiting for it.

On the top of the machine is a water tank from which the required quantity can be discharged through a bent pipe leading into the drum on the loading hopper side.

Points to Watch when Selecting a Mixer

There are a number of different makers of these mixers, and it would be invidious to criticise any particular make. It will be sufficient to point out likely sources of trouble and to leave the reader to form his own opinion of any which he thinks of buying.

Robust Construction is Essential

Competition has resulted in some mixers being sold at too low a price. This has led to lack of robustness and should be carefully guarded against.

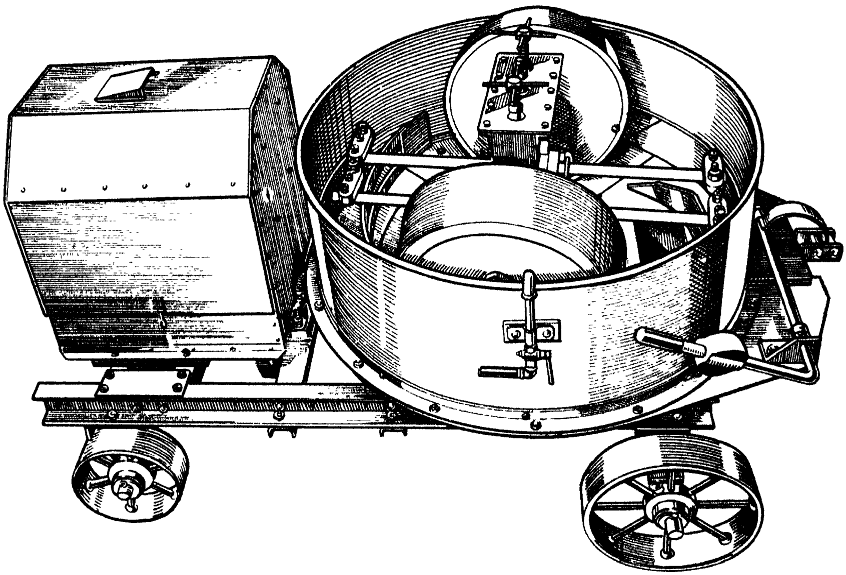


Fig. 3.—A ROLLER-PAN MIXER DRIVEN BY A PETROL ENGINE
The most suitable mixer for lime, sand, mortar, or breeze concrete. The rollers reduce the aggregates to uniform size.

The normal mixer has to stand on rough and uneven ground, has to stand being towed over all sorts of obstructions, and if unsprung must possess a very rigid undercarriage if the whole frame is to remain rigid. If lightly built it will rack, with the result that the track rollers supporting the drum, and the various countershafts concerned with transmitting the engine power to the drum and the loading hopper, will be thrown out of line.

The undercarriage is generally carried on axles, which may be of solid square-section steel or of welded tube. Iron wheels are fitted, two of which serve for steering when the machine is moved. With centre-point suspension of the steering axle one gets three-point suspension. On lifting the loading hopper, which is done by a pull exerted high up on the machine, the whole load of hopper and aggregate tends to turn the machine over on its side, and it becomes necessary to fit some form of adjustable screw or clamp jack which will convert the three-point suspension into a four-point one. Another objection is that, with the iron wheels usually fitted, steering becomes very difficult when either of the steering wheels meets a stone. To use three men to hold a jibbing tow bar, when only one is required with the motor-car type axle, adds to the cost of the concrete.

The track rollers are now usually mounted in pairs on shafts carried at each end in ball bearings.

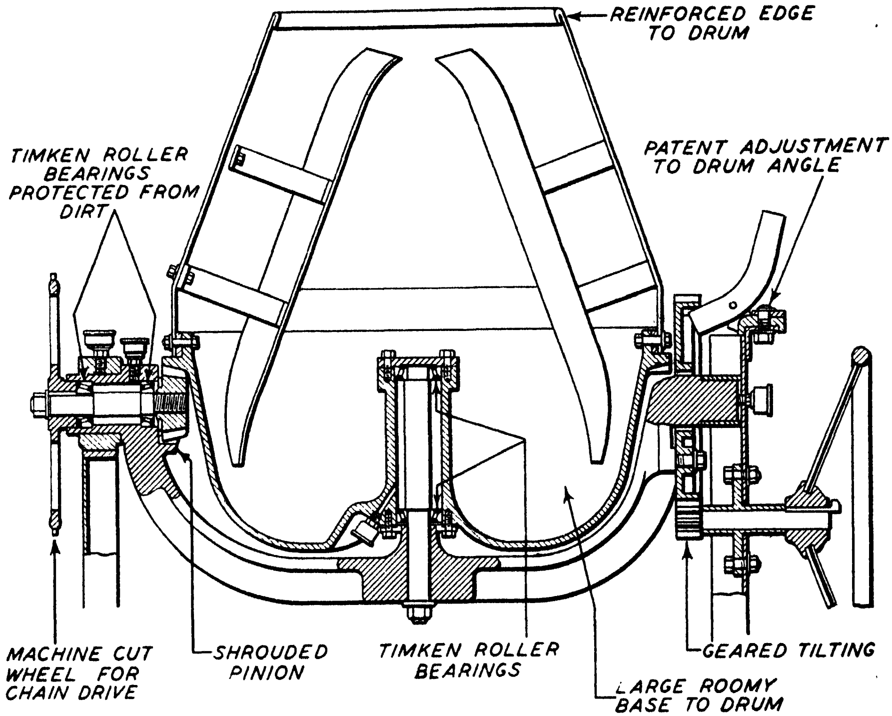


Fig. 4.—DETAILS OF THE DRUM, SHOWING METHOD OF MOUNTING

Although slightly coned so as to keep the drum running centrally between pairs of rollers, these will not function if the machine is not carefully levelled before commencing work, and if the underframe is weak no amount of levelling will keep the rollers level and the drum central.

As the latter is driven by a chain or toothed ring fastened around its outer circumference, side movement of the drum always results in chain or gear trouble.

It is an unfortunate fact that mixer makers always have an excuse when anything breaks, and this applies particularly to ball bearings. If the machine is not level the drum throws a great strain on one bearing of any pair, which is another reason for good and careful levelling. Bearings are occasionally packed with black graphite grease of low quality. This hardens to the consistency of coal and is better forced out and replaced by a good yellow cup grease. If grease-gun nipples are fitted, it should be seen that they are accessible but not exposed to splashings of wet concrete which will result in their being obscured and forgotten.

The Discharge Mouth of the Loading Hopper

In order that the wet concrete in the drum may not splash out, the openings in the endplates are kept as small as possible, with the result that the discharge mouth of the loading hopper is also restricted. Unless this mouth fits well inside the drum aperture when the loading hopper is raised there will be a spill of dry cement, and the clearance being kept small to avoid this, a side movement of the drum causes cutting of the hopper mouth.

As the loading of the drum depends upon rapid discharge from the hopper, any damage to its surfaces is a source of trouble, especially near the lip—which is one more reason for levelling.

Although all makers claim that their hoppers rise far enough to allow the whole of the dry load to run instantaneously down the inside of the hopper, they nearly all fit a rapping device which, striking the discharge lip, vibrates the whole loader. As it is a common thing to see men beating the under side of the loader with a sledge hammer, there would seem to be good reasons for making quite sure, by inspection of a machine in work, that it does give a clean discharge.

Once a hammer has been used the under-side metal becomes pimpled and the discharge becomes worse and worse. A good precaution is to bolt a piece of 9-in. by 3-in. deal to the under side before the mixer starts its job, using cup-headed bolts so as to offer as little internal obstruction as possible.

Raising the Loading Hopper

The raising of the loading hopper is carried out by engaging a clutch connecting the engine to a shaft carrying two winding drums. A wire rope on the drums passes from one to the other by way of grooved wheels pivoted to the loading hopper, or by way of a tube fastened to the same. This latter construction allows the rope to slide slightly through the tube, so that in the event of the rope on one drum mounting on itself, and thus winding in more rapidly than on the other, there is no twisting of the hopper. This method is simple and effective, but if not adopted necessitates the use of a bevel-gear differential action on the winding-drum shaft, and the former would appear to be the better method.

Failure to Declutch Winding Device

As failure to declutch the winding device, when the loader reached the top, would result in the engine trying to drag the loader through the machine, some makes have an automatic device known as a knock-out gear, which performs or should perform the declutching action at the critical moment. If it acts too soon the loading hopper must be moved twice, or it will not have risen to a steep enough angle; if too late the wires will break or the clutch gear be damaged. For these reasons the knock-out gear should be very strongly made, fitted with large, easily

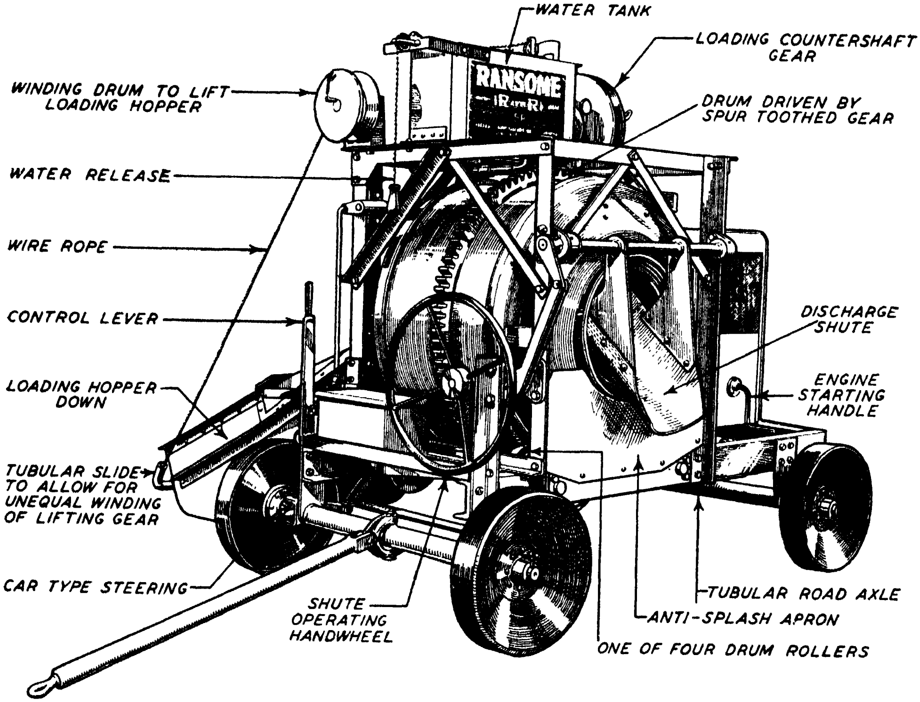


Fig. 5.—A TYPICAL EXAMPLE OF A LARGE PETROL-DRIVEN CONCRETE MIXER
This mixer takes a charge of 10 cu. ft. of aggregate and cement and delivers 7 cu. ft. of wet cement at each batch.

lubricated, pivot pins, and above all be guarded so that stones cannot fall from the raised loading hopper and wedge themselves between the knock-out lever and the main frame.

The Water Tank

The form of the water tank has to satisfy several requirements. It must be as small as possible to keep the head room of the mixer low; it should have some arrangement to allow of continuously uniform discharges of the water; it should be so placed and made as to prevent ingress of stones, which have an unfortunate habit of getting into the more delicate parts of the water system; and should be easily got at when adjustments are required.

In some makes the water is discharged by a syphon action as in some water-waste preventers; in others the water is actually weighed, whilst one or two makers use rubber-seated valves with their stems protruding through packing glands in the bottom of the tank, where they can be actuated by a lever moved by the driver so that he can use his own judgment, assisted by a water-level gauge, as to the amount passed to the

mixing drum. Glass gauges or level tubes are apt to get broken and are easily obscured by splashings of concrete or the blown dust of cement, and other methods seem to be less likely to give trouble.

Unless the tank is totally screened it should be cleaned out once a week, for in its inaccessible position high up on the frame it easily becomes charged with stones and grit which interfere with the operation of the discharge valves.

One type of mixer has rubber-tyred drum rollers and these render it quieter and less liable to jumping than is the case with iron treads. With the latter there is also a tendency for the drum tyres to develop flats, thus changing the circular tread into a polygonal figure ill adapted to free turning on the track rollers. It is possible to have new tyres rolled and welded to the drum, but as they have to be trued in a lathe afterwards it is an expensive process and the ten or twelve pounds spent in this way would be better invested in a new drum.

All mixers wear out, and it is well to inquire the cost of spare parts before purchasing a new machine. All spare parts should be obtainable from the makers themselves, as they have a fund of experience which determines the best type of material to use in such parts as are subjected to heavy wear, and have in addition dies for their accurate manufacture.

The latest practice with mixers is to carry the countershafts as low as possible on the frame, with the result that the clutch which serves to disengage the drum drive from the engine is exposed to more than its share of dust and dirt. Although the mixer engine can be started with the drum "in drive" it is as well to remember that some emergency may demand the instantaneous stopping of the drum, and good guarding of the clutch is therefore essential in addition to frequent testing and lubrication.

Choice of Engine

The choice of an engine for the driving of mixers is generally made by the makers, but a few offer alternatives.

Two-stroke engines are a little lower in price but may be troublesome in inexpert hands.

As all mixer engines are throttle-governed, it is also well to satisfy oneself as to the sturdiness and wear-resisting qualities of the links which carry the governor action to the throttle.

The fuel pump should preferably be mechanically driven and of the plunger type as, though apt to leak around the plunger packing glands, they are more robust than those which depend on the vibration of a steel diaphragm operated by alternate crankcase pressure and suction.

The surest way to avoid breakdowns with engines is to keep them clean, so that all the lubrication points can be seen and attended to.

The best method is to purchase lubricating oil in 5-gal. drums, even if it means a few pence extra on each gallon, as it ensures that whilst each

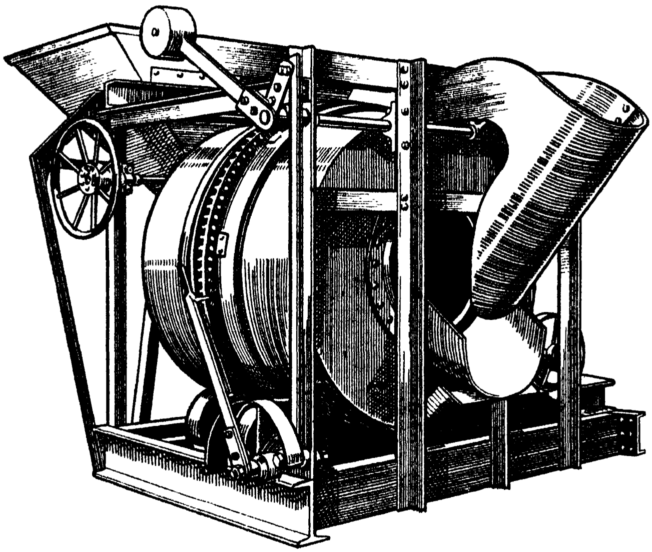


Fig. 6.—ANOTHER OF THE LARGER TYPES OF CONCRETE MIXER
A typical batch mixer with an output of 1 cu. yd. per batch.

driver has a sufficiency there is not the risk of loss that occurs with a 40-gal. barrel.

There is at present a tendency in the direction of high-speed engines running at 1,000 revolutions a minute or over, instead of the usual 400 to 600 r.p.m., and the need for large gear reductions has brought its own troubles. In one case the makers have had to scrap the design, as the racking of the mixer underframe threw the parts out of line. This point should be carefully investigated, as the parts concerned are expensive and easily spoiled unless carefully designed.

To sum up—choosing a substantially built mixer which has not had numerous changes in design will save money in repairs.

The Roller-pan Type of Mixer

Roller-pan mixers have their greatest use when aggregates of large size need to be reduced before mixing, and are therefore of assistance in the preparation of mortar or the making of breeze or brick rubble concrete. They are necessarily heavy, and in the hand-loaded models suffer from a high loading position or a low discharge, but the fineness of the mortar they produce offsets these disadvantages on many jobs. Their portability makes them definitely more useful than older types of mortar pans and they have the additional advantage of serving as concrete mixers or mortar mills, as desired.

A Practical Note on Mixer Outputs

One of the greatest sales points in mixer catalogues is the output of the machine per working day. Whilst it is not suggested that any maker would falsify these figures, it is necessary to point out that they are mostly in the nature of records. In one demonstration the engine was carefully tuned ; the governor spring tension adjusted to give higher revolutions

than normal, and the men loading were undoubtedly out for a record. If a 10/7 machine will turn out 50 yards of well-mixed concrete a day of eight hours it may be taken as capable of filling all usual requirements.

It must be remembered that the loaders will then have shovelled around 80 tons of ballast into the loading hopper, and it is difficult to believe that many men can be found capable of more. The best authorities demand twenty complete cascades of the mix in the drum, which at the normal twenty revolutions a minute takes around a minute and a quarter, allowing for the introduction of the batch. If the hopper discharge is at all slow owing to dirty discharge lips, this time must be increased.

An interesting development in this respect is the use of a drum having several complete helical paddles running from one side of the drum to the other so that the whole batch is passed through to the discharge chute very rapidly. It seems a little difficult to clean owing to the obstruction of the inside of the drum, but may prove to be advantageous when the concrete can be discharged into large-capacity jubilee skips or trucks.

Concerning Continuous Mixers

Many attempts have been made to build efficient continuous mixers, the object being to achieve greater output than is possible when the materials have to be measured into a loading hopper.

As this operation takes place during the time in which the previous batch is being turned over in the drum, it seems an open question whether they can be very much faster, but even if they were, past experience shows that it is very difficult to make a fool-proof feeding device for the cement, with the result that any breakdown to this part of the machine or any inattention on the part of the driver leads to the production of weak concrete, which might be placed in some important part of a structure before the weakness of the mix was detected.

The Double-worm Type

One continuous mixer uses two worms positioned in the bottom of a sloping-sided bin divided by a partition. The ballast and cement being shovelled promiscuously into the two divisions is impelled by the worms on to which they continually fall into a revolving drum of smaller diameter than is usual with closed-drum machines. Here it is cascaded and ejected in the normal manner. By varying the rate at which the worms turn, which can be done by changing the sizes of certain chain sprockets arranged for rapid removal, the proportions of the mix can be altered to suit the requirements of the job.

Other machines use travelling belts fed from slots in the bottom of hoppers kept loaded in the same way. Another type blows a fixed charge of cement into the ballast, but it seems that it is a little early for the small builder to adopt these designs. They are at present chiefly suitable for use by larger contractors.

Conveying a Mixer to the Site

Police regulations debar the towing of iron-wheeled vehicles behind a lorry ; the wheel bearings of the average mixer are plain steel to steel or cast iron and ill adapted to speed, and the best method is to hire one of the specially low-built lorries known as low loaders.

Being fitted with a winch and slides, these allow of the mixer being drawn safely from the ground to the lorry and vice versa.

As hire charges for these lorries are rather high, and as such lorries cannot easily be obtained in all districts, use is sometimes made of a separate towing frame built from two lengths of 6-in. by 2-in. rolled-steel joist and provided with pneumatic-tyred wheels with detachable axles.

The joist frame being placed beneath the mixer, it is jacked up the few inches necessary to allow the pneumatic wheels to be slipped on, and then lowered until they ride. Using this device, the writer has towed 14/10 mixers at speeds of twelve miles an hour, and the first cost of something under ten pounds has been saved over and over again.

Using Concrete Mixers

Even badly handled, a mixer will turn out concrete at two shillings a cubic yard as against six shillings by hand, but properly handled it will do the same amount of work for tenpence. The obtaining of one or other of these two costs is largely in the hands of the foreman, and with a little attention to detail the lower figure is readily achieved.

Importance of a Good Driver

Having requisitioned a mixer from the plant yard, choosing a size in proportion to the amount of concrete in the job, the next step is to obtain a driver. As modern machines are designed to be run by unskilled or semi-skilled labour, this is not a difficult matter, as the extra penny an hour usually paid results in plenty of volunteers ; but it is important to pick a man who is quick in his movements and tidy in his person.

In addition to the extra pay, he should be given half an hour every night, after knocking-off time, to clean and lubricate his charge, and it should be explained to him that this time is to allow him to have the machine actually running as soon as the whistle blows in the morning.

If he has handled mixers before he will have some idea as to what he wants in the way of tools and materials, but if not the following should be ordered to be sent with the mixer.

Tools Required

A good-quality box spanner to fit the sparking-plug of the engine, as any other form of spanner always results in broken insulations ; good-quality open-ended spanners covering $\frac{1}{4}$, $\frac{5}{16}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{5}{8}$, and $\frac{3}{4}$ Whitworth nuts ; a pair of electricians' pliers, a spare new sparking-plug in its original box, a wooden-handled screwdriver, a gallon can of paraffin oil, a half-gallon can of lubricating oil, an oil-feeder, 7 lb. of yellow cup

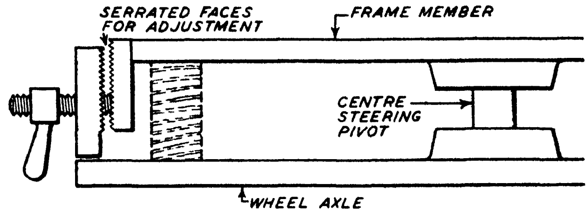


Fig. 7.—TYPICAL JACK FOR MAKING MIXER FRAME SOLID WHEN LEVELLING UP

If the serrations are clogged with dirt or concrete and will not grip, drive in a wooden wedge as shown by dotted lines.

grease, a grease gun, a small tin funnel about 6 in. across, a smaller one about 3 in. across for filling the carburettor chamber, a bundle of old rags (which are better than cotton waste and not so likely to have frayed ends to catch on split pins or moving parts), and a clean new builders' pail about 60-lb. size.

The whole of this kit can be supplied in a box fitted with a lid and padlock, the foreman having a duplicate key in case of illness of the driver.

Placing the Machine

The next point to consider is the placing of the machine, and considerable care should be given to this matter, as it has the greatest effect on the cost of placing the concrete. There is always a temptation to dump the mixer anywhere as long as it is close to the road, but although sleeper track costs money to lay it is far cheaper than lengthy barrow runs.

If there is much concrete on upper floors a hoist will be required, and the mixer should be placed as close to this as is practicable, with a firmly laid platform of deals covering the loading side of the machine, and of such area as will allow of storage of ballast in case of breakdown in supplies. The ideal is to have ballast delivered as fast as it is used, so that it can be tipped close to the loading hopper of the mixer, to avoid the need for trimming.

Preparing the Mixer for Work

As soon as the mixer arrives on the job it should be wiped over with paraffin oil, particularly on the outside of the drum and the frame on the loading side. This will prevent the sticking of splashed concrete.

Importance of Correct Levelling

It should then be carefully levelled in all directions, and this part of the work should be checked by the foreman himself, as no other detail can cause so much trouble. The normal mixer of the closed-drum type has four rollers supporting the mixing drum, and if these are out of level the drum will inevitably run over to one side, wear the rollers unevenly, allow the main drum chain to ride up the sprockets, and cause wear and eventual cutting of the discharge mouth of loading hopper by

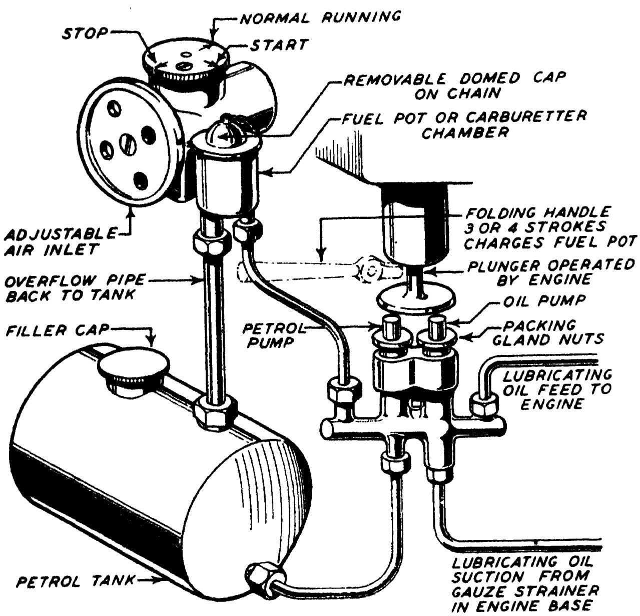


Fig. 8.—FUEL AND LUBRICATING OIL FEED SYSTEMS ON THE LISTER HOPPER-COOLED (FOUR-STROKE) ENGINE

forcing the drum opening against it.

If the Machine Is Fitted with a Central-pivoted Front Axle

In machines fitted with a central-pivoted front axle, care should be taken that use is made of the jacks supplied on the front end of the frame, and if they are out of order through rust or dried cement caking the threads, a wooden wedge should be driven between frame and axle.

An Important Point

If the mixer has been delivered on a lorry it will probably have had the loading hopper detached so as to take up less room in transit. Before reassembling examine the discharge lip, and if it is dented or burred file it smooth, as nothing interferes so much with fast running, and it is more easily got at than when in position on the mixer.

Check all the grease-gun terminals to make sure they have been charged, test the drum-driving chain for slackness, and also the smaller engine-drive chain, and then examine the engine.

Examining the Engine

The Lister, which is commonly fitted to mixers, carries an instruction booklet in a tube on the front of the crankcase, but as it is more often than not missing, common sense must be the guide in locating the lubricating oil filling-plug on the crankcase. See that there is a good level of oil; dip the petrol tank and fill if necessary, and then oil all moving parts with as few drops as possible, paying most attention to the control rods connecting the governor and the throttle.

Whether radiator or hopper cooled, see that there is plenty of water; make sure the cylinder drain-cock works freely.

Starting

Most mixer engines now run on petrol or paraffin, but in both cases are started on petrol. The Petter two-stroke engines have a diaphragm pump built in the side of the crankcase, the pulsations of the diaphragm being caused by the alternate pressure and vacuum in the crankcase as the piston moves up and down. It is necessary to pour petrol into the carburettor chamber before starting. With the Lister engine, fuel is fed from one plunger of a two-plunger pump provided with a hinged handle. Two or three strokes on this handle will force up enough fuel for a start, after which the action is automatic.

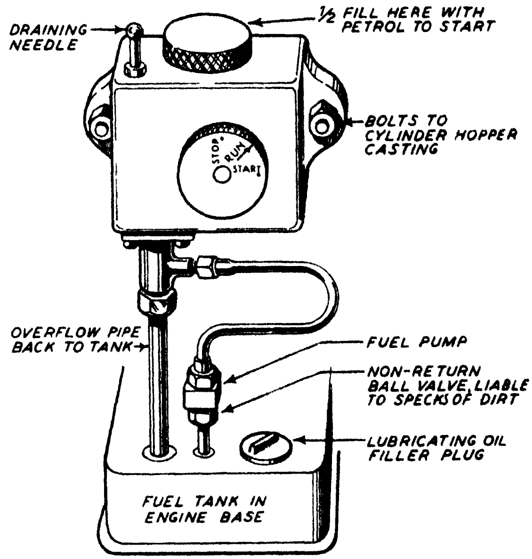


Fig. 9.—FUEL SUPPLY SYSTEM IN THE PETTER TWO-STROKE HOPPER-COOLED ENGINE

This engine starts on petrol and runs on petrol, paraffin, or "Shell Spark."

If the engine has been standing for some time out of use it is well to pour some lubricating oil around the packing-gland of the plunger, as leaks at this point will prevent proper working.

By removing the domed cap on the carburettor it is easy to see whether the pump is in order.

Much futile swinging of the starting-handle can be saved by taking out the sparking-plug and testing the ignition by laying the plug on the cylinder head. A slight turn of the flywheel should be sufficient to give a good spark.

In Cold Weather

On both Petter and Lister engines the large-headed screw controlling the fuel flow is marked with two arrows indicating the running and starting positions, the latter giving a fuller fuel opening than the former. Having replaced the plug, make sure the high-tension lead is on, set the fuel screw, and swing the engine sharply, when it should immediately fire. If the weather is cold and the engine stubborn, a small doping of

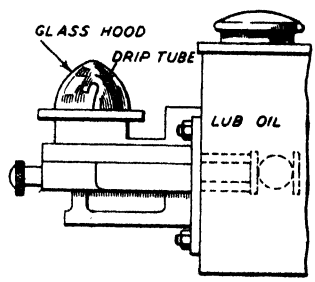


Fig. 10.—PETTER SIGHT-FEED LUBRICATOR FED BY TWO-PLUNGER PUMP IN TANK

petrol through the plug may help, whilst dipping the plug in petrol and lighting with a match to warm it up, and the use of hot water in the radiator or hopper, are helpful.

Trouble Due to Incorrect Timing

No mixer should be sent to a job unless it has been tested, but if it has been sent out in a hurry there may be trouble due to slipping of the timing.

This will not cause absence of spark at the plug but it will give the spark at the wrong time, and it can be checked by setting the engine so that the crankshaft is at top dead centre (which can be seen by having the flywheel keyway uppermost) and then removing the cover from the make-and-break of the magneto. If the points are seen to open when the wheel is rocked back and forth it is unlikely that the fault lies here. If there is a spark at some other point in the revolution of the flywheel, the magneto must be retimed.

With Petter two-strokes started on petrol but run on paraffin, even a few turns of the crankshaft will pump paraffin into the fuel pot, thus diluting the starting-petrol, and it must be drained out by lifting the spring-pressed needle valve alongside the control screw, and a fresh charge of petrol introduced.

The likeliest cause of trouble is a bad plug, which may fire in the open but fail under compression in the cylinder. The remedy is to clean it or use the spare new plug, sending the bad one back for renewal.

The Clutch

When the engine is running satisfactorily, the clutch which engages the drum drive should be tested. Some emergency may call for stopping of the drum in a hurry, and these clutches too often refuse to function. As the engine can be started with the drum in drive no one seems to bother about declutching, but it is a point which deserves attention, for if the engine breaks down whilst a mix is in the drum the latter can be turned round by hand to discharge the contents, whereas if the clutch is stuck the chain drive has to be dismantled.

With the drum turning, check its position on the track rollers. If it does not run central, check the levelling and get it correct before going any further.

The Hopper Loader Gear

Next try the hopper loader gear. Let the clutch in gently and run the hopper up and down two or three times, thus also testing the lowering brake. If fitted with automatic knock-out gear, try this out by pulling the clutch lever over to the raising position, and stand away. If it fails the wires will probably snap, but it is better to find this out with an empty hopper when you are ready for it than with a full one when you may be standing under it.

Coating a New Drum with Cement

Fill the water tank by hose or hand and try the water discharge, emptying the drum through the discharge chute on the other side. If satisfied with the tests the drum can be given a few shovels of cement to coat it if it is at work for the first time, as the small nooks and crannies will otherwise rob the first batch of cement and weaken it.

Loading the Hopper

In loading the hopper make it an invariable rule not to exceed the correct load. If it is a 7/5 mixer do not go above 7 cu. ft. of materials, if a 10/7 do not exceed 10, and so on. There is nothing to be gained by overloading, and everything to lose. When the hopper is raised it will strain the whole frame of the machine, stretch the wire ropes, damage the clutch, and bend the loading-hopper frame. When at the top of its lift the hopper will spill a lot of its contents on to the machine instead of into the drum, and if the overload gets safely inside the latter it will be splashed out before it is discharged from the chute.

Capacity of a 7/5 Mixer

Properly used a 7/5 will give 50 to 60 cu. yd. of concrete in eight hours. If the job requires more it should have a second or a larger machine. Overloading can easily cost £30 in repairs and a loss of anything up to a week whilst the parts are being replaced, so is on every count a losing proposition.

The Correct Way to Load

The most convenient method of loading is to have two men, one being given the extra job of loading the cement. Ballast should be shovelled in so as to slope against the sides and bottom of the hopper, the cement poured in or the bag broken if it is a one-bag mix, the heap being left undisturbed whilst filling is completed with ballast. When the hopper is raised the sandwich of ballast and cement will slide freely into the drum, whereas if the cement be placed in last the ballast will run first, leaving the cement to stick to the sides and lip of the hopper.

Under no circumstances should the under side need hammering to obtain a full and complete discharge. If it does, either the hopper is not being allowed to rise high enough, or the lip is dirty or rough.

Adding the Water

Some mixers have a synchronised water control which allows the mixing water to enter at the correct moment, but in machines not so fitted care should be taken that the bulk of the water is added to the drum as the mix starts to enter the drum, or the inclined paddles will carry some of it through the drum to the chute side so that the earlier

part of the mix will be very wet and the latter part dry. About 1 gal. should be allowed in before the mix, so as to wet the drum.

Output

Output of machines is based usually on ten-second loading and one-minute mixing at twenty revolutions of the drum, but the new ideas on dry mixing will probably result in the need for longer periods—up to two minutes per batch. Complete discharge should take about ten seconds, but if into wheelbarrows will of course depend on the quickness of the barrow men. They will be assisted by the use of pneumatic-tyred wheels, broad running-planks, and a wide, planked space for manœuvring up to the chute.

The engine will give its own warnings of incipient trouble: misfiring, steaming of the hopper or radiator, reluctance to lift the hopper load, should all be attended to at the earliest opportunity; but other failures can only be detected by examination when the machine is stationary. It is a good plan to feel all bearings after each four hours of running, and to take prompt steps to force more lubricant into any that are unduly warm.

This sort of attention becomes an acquired habit, need take only a few moments, and is well worth doing.

Cleaning the Mixer after Use

At the conclusion of the day's work the interior of the drum should be cleaned by loading a couple of cubic feet of ballast and water into the drum, allowing it to turn around for several minutes before discharging it. The hopper should then be brushed out and the lip carefully cleaned so that there is no trace of cement to spoil its surface. Once pitted the hopper is spoiled.

Drain the Cooling Hopper Once a Week

Although not necessary in warm weather, it is advisable to drain the cooling hopper once a week to prevent the caking of lime or sand deposits in the cylinder-head passages or the drain-cock. Should there be a stoppage, it is a pity to leave it until a frosty night results in a cracked cylinder. Poking with a bent wire usually clears the trouble, but in obstinate cases the water should be syphoned off with a short length of hose and a pint of spirits of salt poured in and left for, say, half an hour. Its action can be watched, and when it stops effervescing more acid should be added until the wire finally gets through. The acid should then be well washed out before refilling.

Maintenance Notes

At least once a week the engine crankcase should be drained of oil, the wire-gauze filter removed and cleaned, and new oil filled in to the correct level.

Chapter VI

FORMWORK FOR CONCRETE BUILDINGS

THE weight of concrete depends on the aggregate of which it is composed. It may weigh about 130 lb. per cubic foot, and until it sets, the formwork must be capable of taking the weight and withstanding the pressure of the mixture.

Pressure on Formwork

Freshly mixed concrete, like water, exerts equal pressure in all directions, so the depth of the wet mixture governs the pressure. Fig. 2 shows a column 10 ft. high, and assuming it to be filled in one shift, the pressure per square foot at the bottom would be approximately 1,300 lb. In other words, with every foot in depth of concrete "placed," 130 lb. pressure is added to the bottom layer. In the case of formwork for girders and beams, it is the dead weight of the material, rather than the pressure, which must be considered. The pressure on the sides of girders of, say, 12 in. to 15 in. deep would be about 65 lb. to 70 lb. per square foot. Nails driven through the sides into the edge of the bottom board are sufficient to take this pressure.

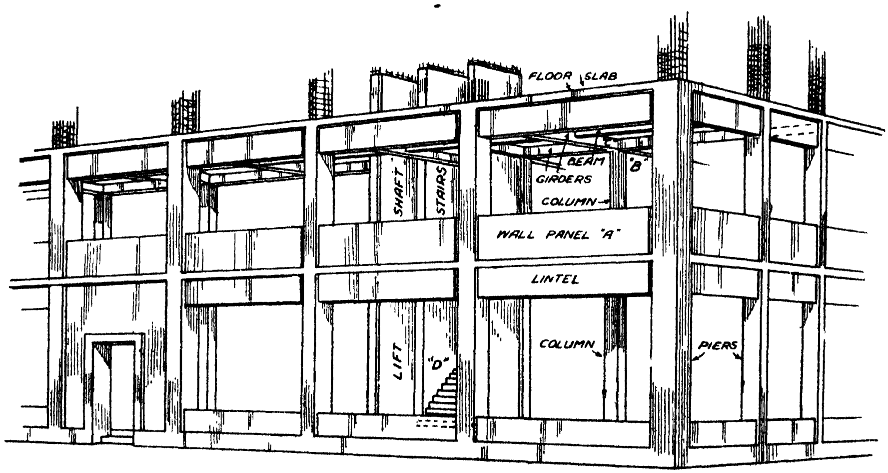


Fig. 1.—General construction of a reinforced-concrete building

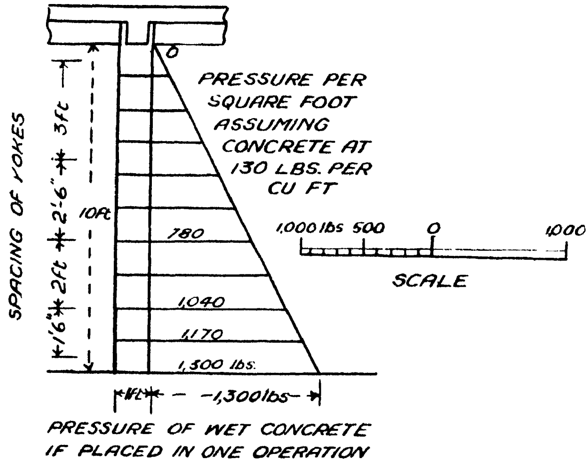


Fig. 2.—SHOWING PRESSURE EXERTED BY WET CONCRETE

Nailing Formwork

To facilitate "stripping," formwork should be nailed as lightly as possible. If wire nails are left with their heads scarcely driven home, they can be drawn out with a claw hammer, and thus avoid jarring the concrete. Nails driven slightly on the angle will not only hold better, but will be easier to draw.

Spacing of Yokes

As the pressure is greatest at the bottom of a column, diminishing to nothing at the top, it follows that yokes should be spaced closer together where the pressure is most, to prevent the panels bulging. The thickness of the boarding used for panels will also influence the spacing. If 1-in. boarding is used, the two bottom yokes of a 10-ft. column, which is filled in one operation, should be not more than 18 in. apart, and the others as shown in Fig. 2. It is common practice to make the forms for columns a little more than half the complete height, to " place " the concrete, and when this has set sufficiently hard, to move the half-form up and place the remainder. In such cases the yokes may be spaced for the upper half as shown in Fig. 2.

Timber for Formwork

If the finished surface of the concrete is required to be left smooth, the boarding must be " thicknessed " as well as wrought to avoid ridges.

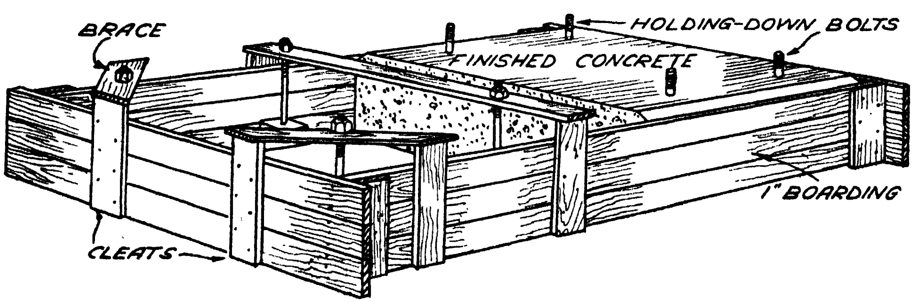


Fig. 3.—FORM FOR CONCRETE MACHINE BED

If, however, the surface is to be plastered, a rough and ridged surface will be an advantage in providing a " key " for the plaster. If the timber is " bone dry," it tends to " cast " and swell when the wet mixture is placed, and in wide panels this might be considerable. Bevel-edged boarding (as shown in detail, Fig. 4) may be used ; the sharp edges will " give," and avoid the accumulated expansion over the whole panel. By damping the outside of the panel, casting will also be avoided.

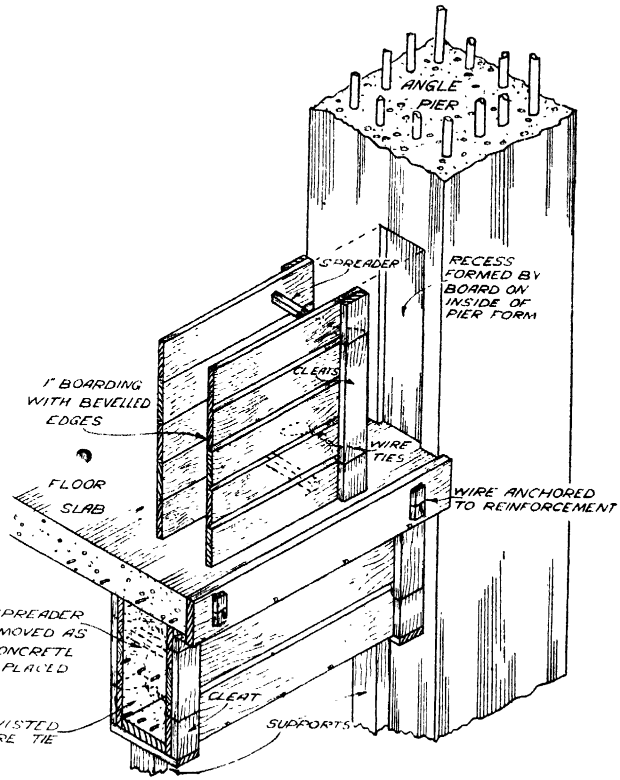


Fig. 4.—DETAIL OF FORMS FOR LINTEL, EDGE OF FLOOR SLAB AND WALL PANEL AT A IN FIG. 1

One-inch boarding is usual for the panels of columns and the sides of girder forms. Bottom boards of beams and girders are better to be $1\frac{1}{2}$ in. thick, they will hold nails better.

Treatment of Formwork

A coat of soft soap and water or mould oil on formwork will facilitate stripping, and leave a better face on the concrete.

Form for Machine Bed

Fig. 3 shows the method of constructing the form for a machine or engine bed. The hanging pieces at the angles also act as braces.

General Construction of Formwork

Fig. 1 shows the general construction of a reinforced-concrete building as a guide to the details which follow.

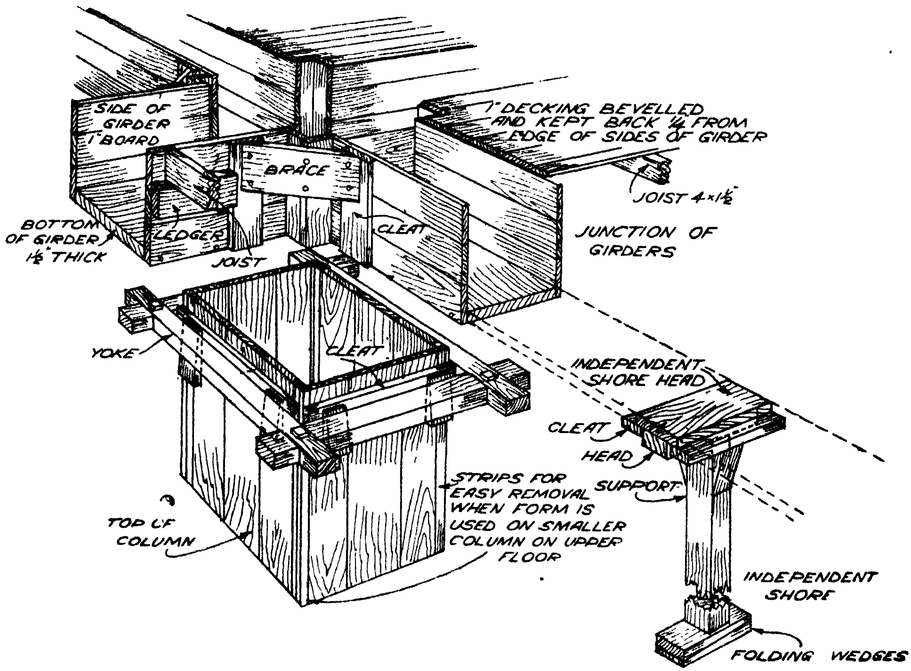


Fig. 5.—FORMS FOR JUNCTION OF GIRDERS AT B IN FIG. 1

Wall Panels, Spreaders, and Ties

Fig. 4 shows the detail of forms for lintel, edge of floor slab, and wall panel at A in key sketch. " Spreaders " are wedged between the sides to maintain the correct space, and wire ties, passed between the boards, round the cleats, and twisted as shown, take the pressure. The spreaders are removed when the concrete reaches their level. The wire ties are cut off close to the surface of the concrete, and punched below the surface, which is afterwards made good. The board for the edge of the floor slab is fixed by wires anchored to the reinforcing rods, and secured as shown.

Bevel-edged Boarding

For the reason already stated, bevel-edged boarding is used on the exposed face of the wall, while square-edged boards are used on the inside. If the joints of the inside sheeting are left slightly open, excessive swelling over the whole panel will be avoided. Expanded metal, which is held in place by the spreaders, bridges the joints between the boards, adheres to the concrete when stripping is done, and provides a key for the plaster.

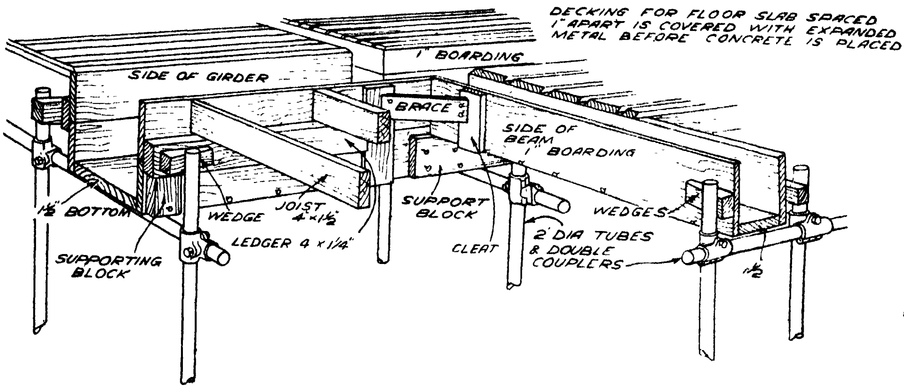


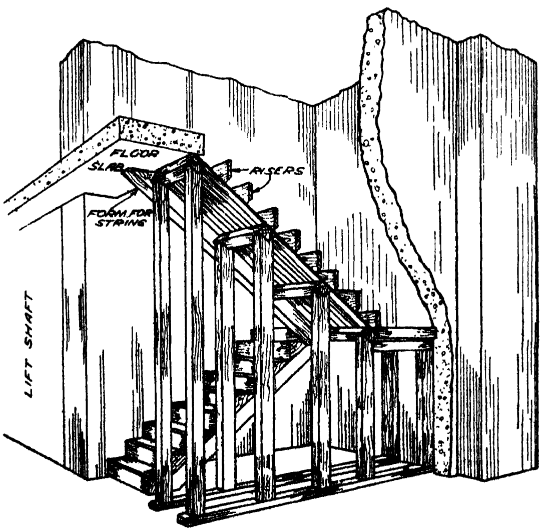
Fig. 6.—Formwork at junction of girder and beam at C in fig. 1

Junction of Girders

Fig. 5 (detail at B in key sketch) shows the junction of girders and the top of the column form. The column form is shown with narrow strips at either edge, which when removed will make up the size of the form for the column on the next floor. The yokes are halved at the angles and bolted, and wedges keep the sides tightly in place.

Independent Shores

When the formwork is stripped, for use on the next floor, it is advisable to leave one or more shores for a longer period under girders, to guard



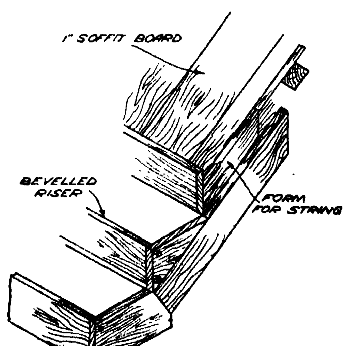


Fig. 7A.—Detail of string and bottom step

Fig. 7.—Formwork for concrete stair at D in fig. 1

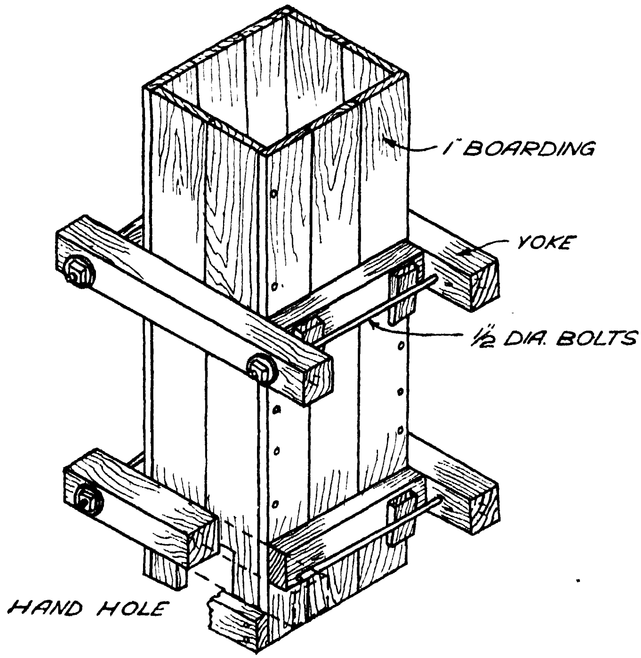


Fig. 8.—DETAIL OF FOOT OF COLUMN

against stress in the still rather "green" concrete. In Fig. 5 an independent shore is illustrated. The bottom board rests on cleats, and folding wedges are provided at the foot to allow for easy removal when that can be safely done.

Clearance

In case the sides of the girders bulge slightly, and the concrete grips the ends of the "decking," the edges of the decking should be bevelled and kept back about ¼ in. from the edges of the girder (see Fig. 5).

Junction of Girder and Beam

The junction of a girder and beam is shown in Fig. 6 (detail at C in key sketch). Here the decking is shown, with spaces of about 1 in. between the boards. Fine-gauge expanded metal bridges the gap, and forms a key for the plastered ceiling.

Supports for Formwork

Tubular scaffolding is shown supporting the formwork. It can be used time and again, so apart from first cost it is in the end most economical. Shores which can be adjusted to suit the required height are obtainable, and are extensively used.

Stairs

The form work for stairs in concrete is shown in Fig. 7 (detail at D in key sketch). Fig. 7A shows a detail of the string and bottom step. The studs supporting the soffit boarding should be racked together ; the

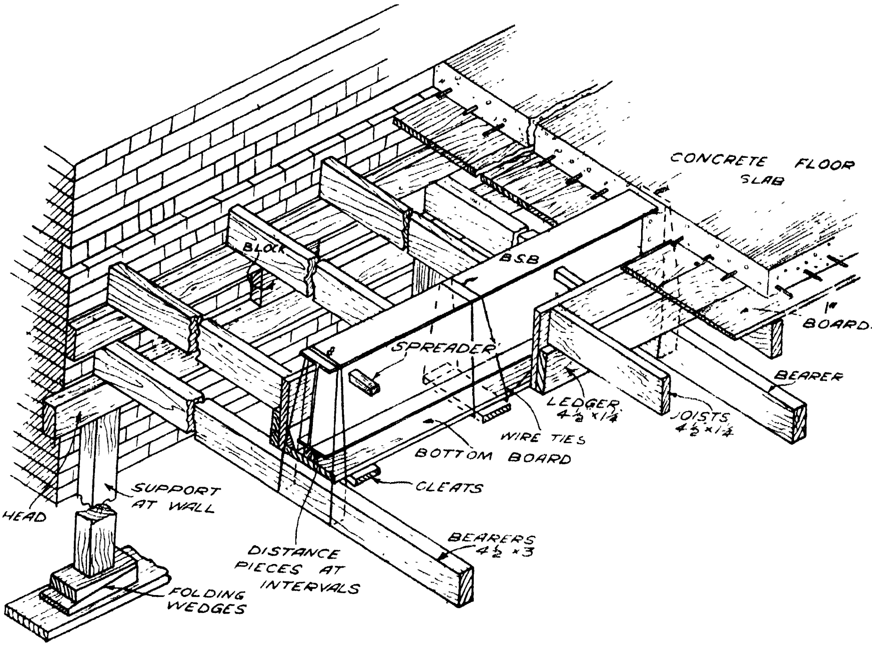


Fig. 9.—SUSPENDED FORMWORK

racks are not shown in the sketch. The concrete is finished level with the top of the risers, which are bevelled on the bottom edge to allow the floating off of the surface to be performed.

Hand Hole

Shavings and other rubbish are apt to collect at the bottom of column forms. If a small hand hole, as shown in Fig. 8, is provided, rubbish can be removed just prior to the concrete being placed. Another type of yoke is here shown, in which ½-in. diameter bolts are used to keep the sides tightly together. The end panels are nailed direct to the yokes, and wedges driven between them and the bolts.

Suspended Formwork

In steel-concrete construction, the beams are used to support the forms for the haunch, soffit, and decking of floor slab. Wire ties, at intervals according to the weight to be carried, are passed between the sides and bottom boards to support bearers, as shown in Fig. 9. The bearers take the weight of the beam form, and additional support may be given by ties at intermediate cleats. Spreaders between the web of the beam and the sides maintain the correct width. Distance pieces (small

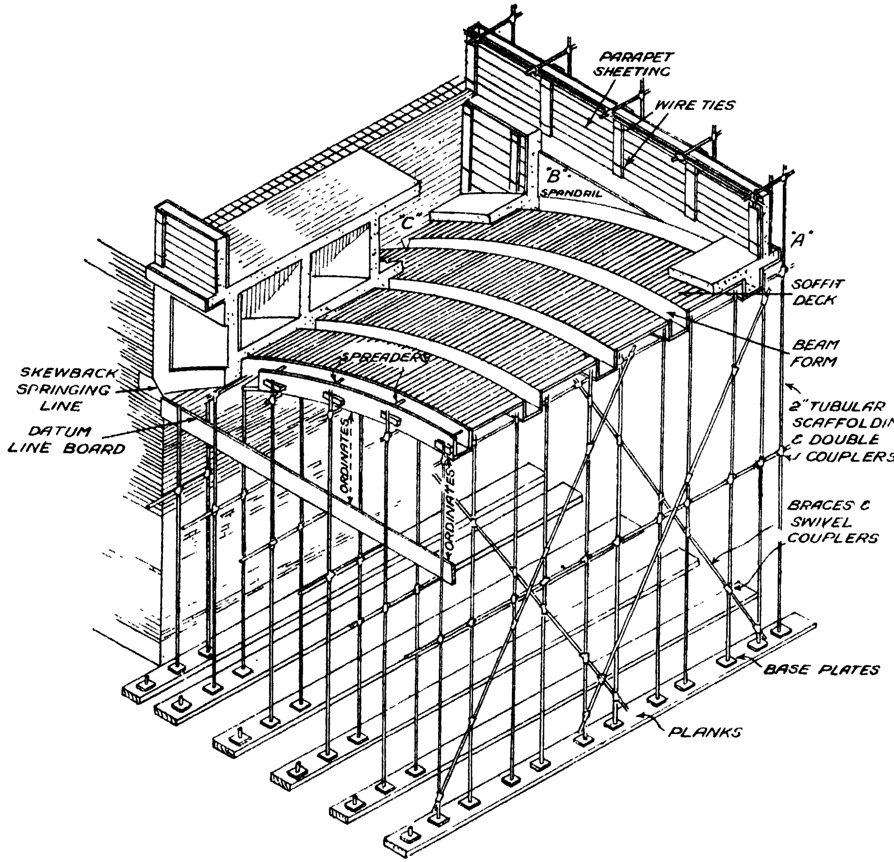


Fig. 10.—FORMWORK FOR BRIDGE

pieces of concrete) at intervals under the bottom flange ensure the correct thickness of concrete. The ledgers on which the joists rest are supported by the bearers, and lightly nailed to the sides. The decking is bevelled where it rests on the sides of the beam, and is kept back $\frac{1}{4}$ in. from the inside edge for the reason already stated. The method of supporting is shown where the floor abuts on a wall.

Bridge in Reinforced Concrete

Fig. 10 shows the general construction of the formwork for a bridge in reinforced concrete. A datum-line board is fixed at the level of the spring of the arch, and from this, ordinates are taken to the underside of the curve. Horizontal tubes are fixed at these points, and the weight per foot super to be carried will govern the number of supports required.

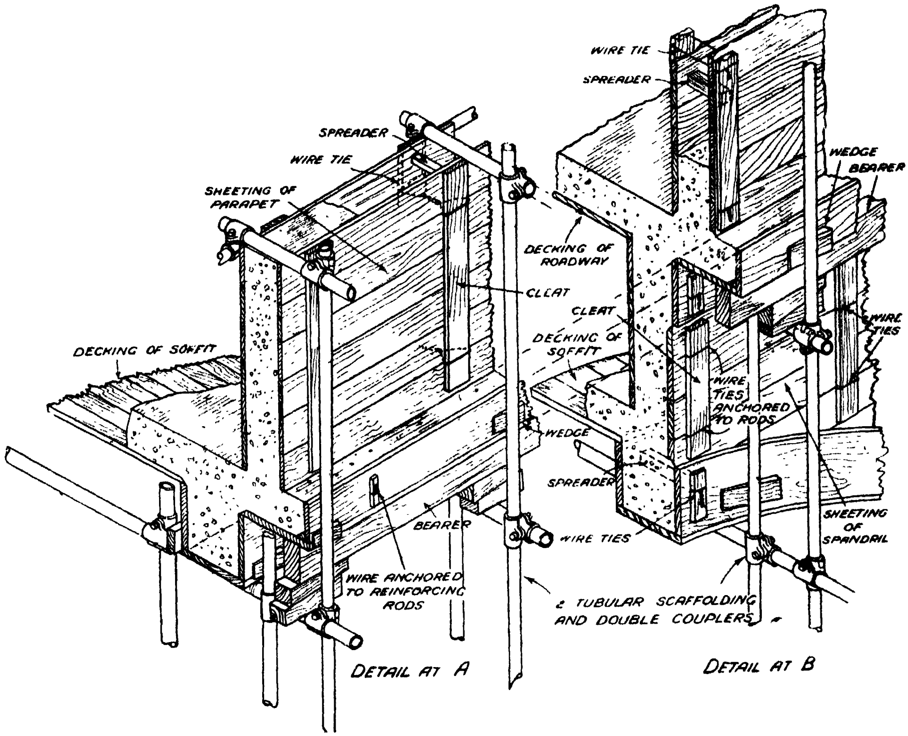


Fig. 11.—ENLARGED DETAIL OF A AND B IN FIG. 10
The top of the parapet form is stayed by securing it to a tube on the inside.

Wedges, between the sides of the beams and the top of the tube supports, keep the sides in alignment and take the pressure. Spreaders to maintain the correct width are required for the outside beams; for intermediate beams this is done by "tacking" the soffit boarding at intervals. In order that beam forms will "drop" when the stripping is done, the ends must be cut off vertical at the skewback, and a wedge-shaped portion made up to complete the curve, as shown at C.

The Top of the Parapet Form

Details at A and B are shown in Fig. 11. The top of the parapet form is stayed by securing it to a tube on the inside. The construction and details of these forms follow closely on the lines of those already described.

Metaforms

Steel forms, as illustrated and described in Figs. 12 and 13, are obtainable. Metaforms for circular work can also be supplied.

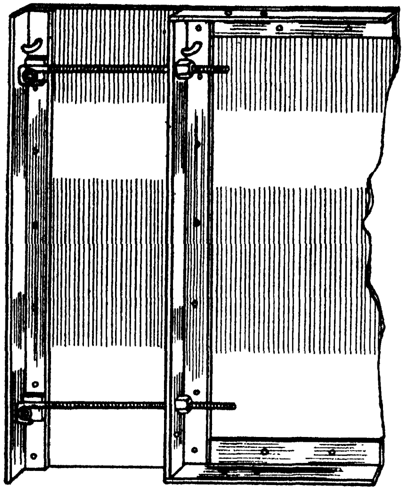


Fig. 12.—ADJUSTABLE "METAFORM" UNIT FOR CONCRETE CONSTRUCTION

The steel units are assembled into walls of required length, height, and shape, and each unit is clamped to its neighbour by unbreakable malleable clamps. These units are particularly useful for adjusting the overall length of the formwork assembly.

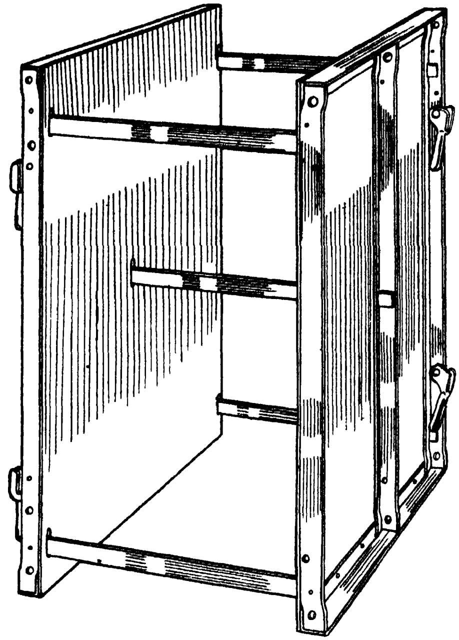


Fig. 13.—"METAFORM" STEEL SPREADER TIE SHOWING THE USE OF THE MAXIMUM NUMBER OF SPREADER TIES

Striking the Shuttering

Shuttering should be left in position as long as possible. The minimum time which should be allowed between the placing of the concrete and the striking of the forms depends upon the position in the structure, the climatic conditions, and the quality and setting-time of the cement. The minimum intervals for work done in normal weather, with a temperature of round about 60° F., will be as follows :

	Normal P.C. Concrete	*Rapid-hardening P.C. Concrete*
Beam Sides, Walls, and Columns . .	3 days	2 days
Slabs (props left under) . . .	4 ,,	3 ,,
Remove props (to slabs and beams; soffit props left under)	10 ,,	5 ,,
Remove props to beams . . .	21 ,,	10 ,,

All props must be eased slowly, and care must always be taken when striking the shuttering, so as not to jar the concrete unduly. For concrete mixed with aluminous cement, the whole of the supports can be removed after 40 hours, and with beam sides, walls, and columns, after 12 hours.

Chapter VII

TEMPORARY TIMBER CENTERING FOR ARCHES

MANY variations in " centres " are required between the simple " turning piece " in Fig. 1 and the 20-ft. framed centre in Fig. 11. Their shapes and construction may vary, but their purposes are alike, viz. to give temporary support to an arch until it is capable of supporting itself.

Load on Centres

The shaded part in Fig. 2 shows the area of walling actually supported by the lintel. The mass of brickwork above the shaded portion, and between the broken lines, is transferred to the piers by the corbelling of the joints above. If an arch, following approximately the line of the corbelling, replaced the lintel, it would carry practically nothing but its own weight. This is true when the mortar in which the bricks are laid is set, but until that takes place a certain amount of weight must be carried by some temporary support.

Form of Arch Influences Load

Fig. 3(*a*) shows an equilateral arch which will throw little weight on the centre, the curve of the " intrados " being steep. The centre in Fig. 3(*b*), having a flatter curve, will be subjected to a greater downward strain. The semicircular centre in Fig. 3(*c*) is something between the other two.

Construction of Centres

The shape and size of the opening will govern the number of parts which are required to make up the " rib " and the number of parts will decide the bracing. Fig. 3(*a*) shows a centre in which only two pieces are necessary for the complete rib, each piece being cut from a board 9 in. wide. In Fig. 3(*b*) four pieces are required, whilst in Fig. 3(*c*) six pieces are shown, assuming all the pieces to be cut from 9-in. stuff. By using wider boards the number of pieces forming a rib could be reduced, but this would mean more " cutting to waste," therefore it is less economical.

Stresses on Centres

When the " voussoirs " at the " haunches " of an arch, as in Fig. 3(*c*), are placed in position there is a tendency for the " crown " to be forced

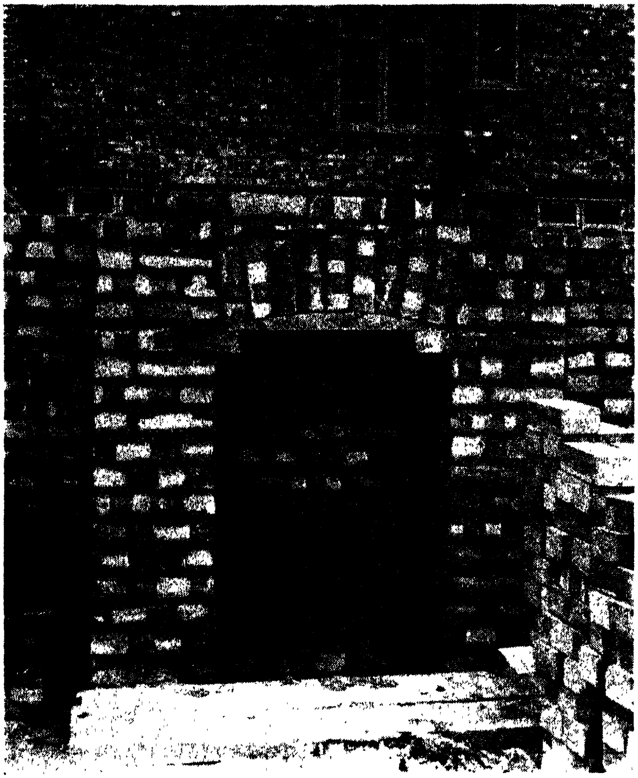


Fig. 1.—WOODEN CENTRE FOR FORMING ARCH OF FIREPLACE OPENING

upwards, so it must be tied down as suggested by AB. If the tie were weak it would also tend to bend upwards, so it must be kept down by the braces CB and DB, which the loading at the haunches will accomplish.

Rigidity

To withstand distortion at different stages of loading, a centre must be well braced. If the braces and ties are well placed to take the strain, even large centres (for openings in walls) may be constructed with boarding 1 in. to 1¼ in. in thickness.

Setting Out Ribs

If the curve is a segment of a circle, set out the span XY as shown in Fig. 4 ; at Z, the middle point of the span, draw ZC at right angles to XY and mark off ZC equal to the rise. Join XC and YC—A is the middle point of XC. Draw AD at right angles to XC, and produce to cut CZ produced to D—D is the centre for the curve. As a check, draw from B a line at right angles to CY ; it

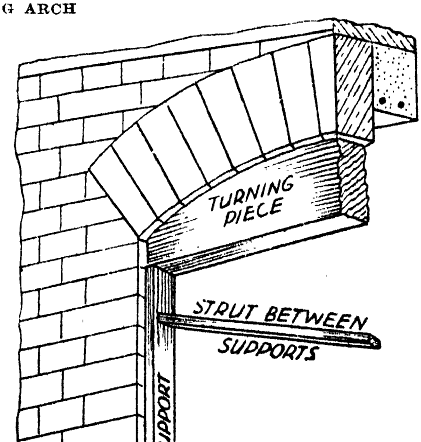


Fig. 1A.—SIMPLE TURNING PIECE CENTRE

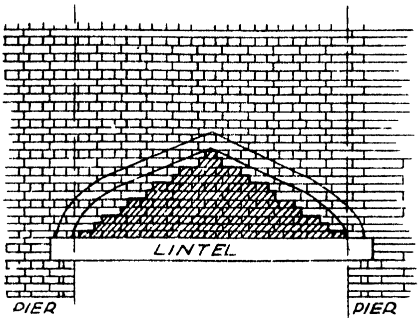
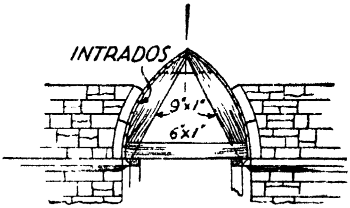
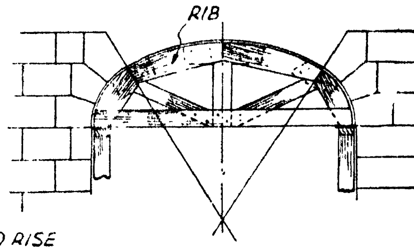


Fig. 2.—ILLUSTRATING PRINCIPLE OF ARCH

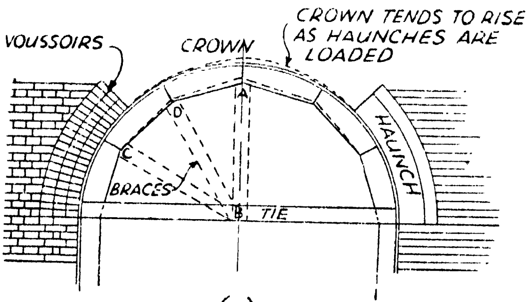
If an arch, following approximately the line of the corbelling, replaced the lintel, it would carry practically nothing but its own weight—after the mortar had set.



(a)



(b)



(c)

Fig. 3. HOW FORM OF ARCH INFLUENCES THE LOAD ON THE CENTRE

(*a*) An equilateral arch throws little weight on the centre. (*b*) Semi-elliptical centre is subjected to the most downward strain. (*c*) Semi-circular centre is subjected to weight something between that in (*a*) and (*b*).

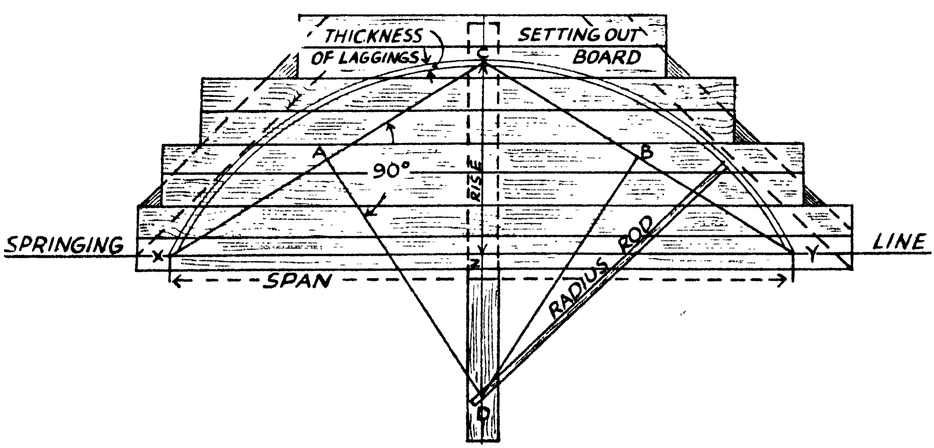


Fig. 4.—SETTING OUT RIBS FOR CIRCULAR CENTRE ON SETTING-OUT BOARD

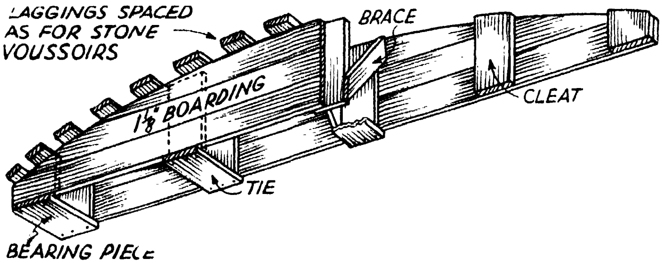


Fig. 5.—Solid-rib centre for arches with low rise in relation to span

should cut CZ, produced, at D. Fix a thin lath with a bradawl at D, cut it to the length DC less the thickness of the lagging. This will be the radius rod for the curve.

Solid-rib Centres

For arches with a low rise in relation to the span, solid-rib centres are best (see Fig. 5). They are rigid and well suited to take heavy loading.

Concentric Arches

Fig. 6 shows a centre of two concentric rings suitable for a door or window opening with a rebate for the frame. This centre would be

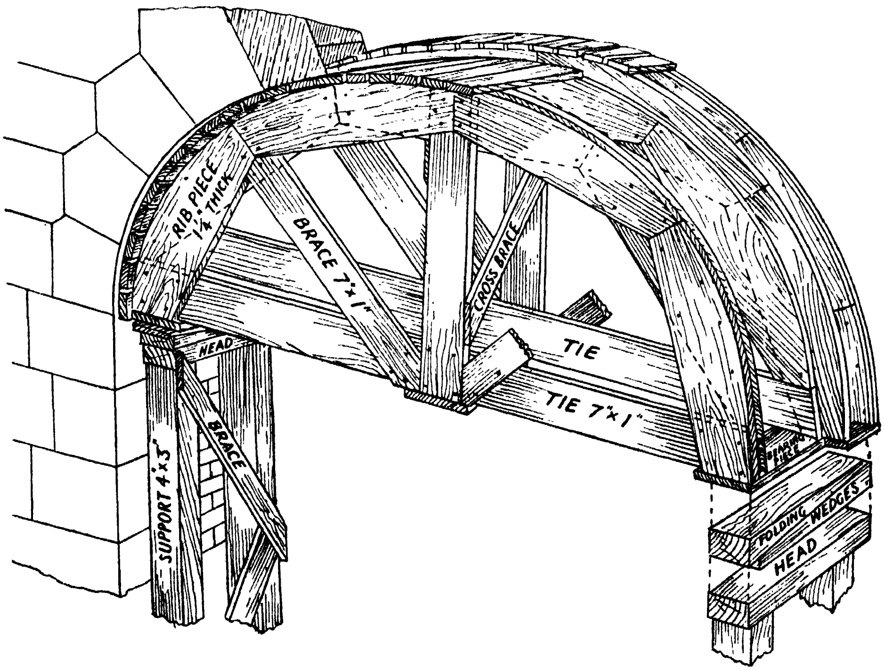


Fig. 6.—Centre for concentric arches

Suitable for door or window opening with a rebate for the frame, and for spans of about 6 ft. to 8 ft. Note methods of supporting and easing by folding wedges.

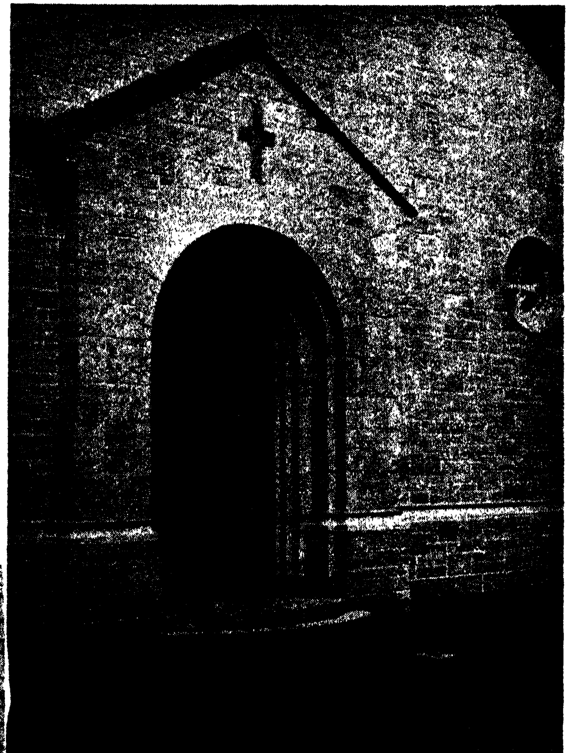


Fig. 6A (*right*).—SEMICIRCULAR ARCH ENTRANCE TO CHURCH AT FOXROCK, CO. DUBLIN
(*Architect : John J. Robinson, F.R.I.B.A.*)

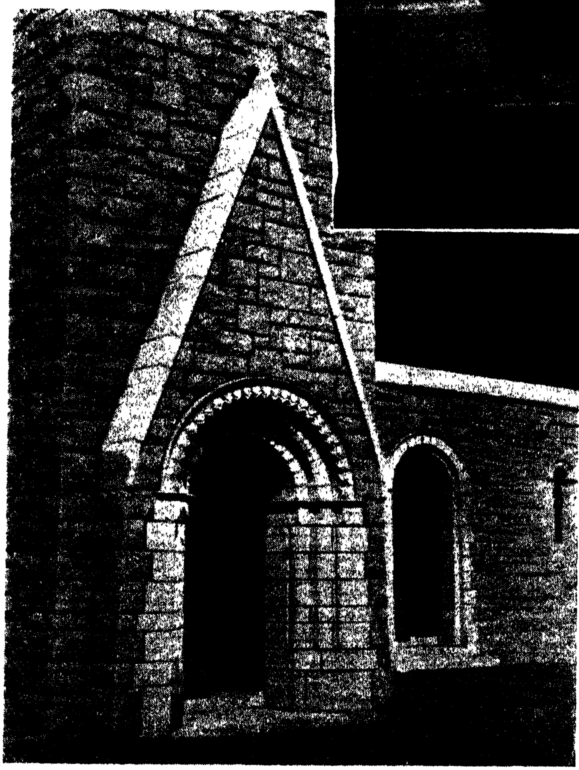


Fig. 6B (*left*).—SEMICIRCULAR ARCH ENTRANCE AT BASE OF TOWER OF CHURCH AT LUSK, CO. DUBLIN
(*Architect : John J. Robinson, F.R.I.B.A.*)

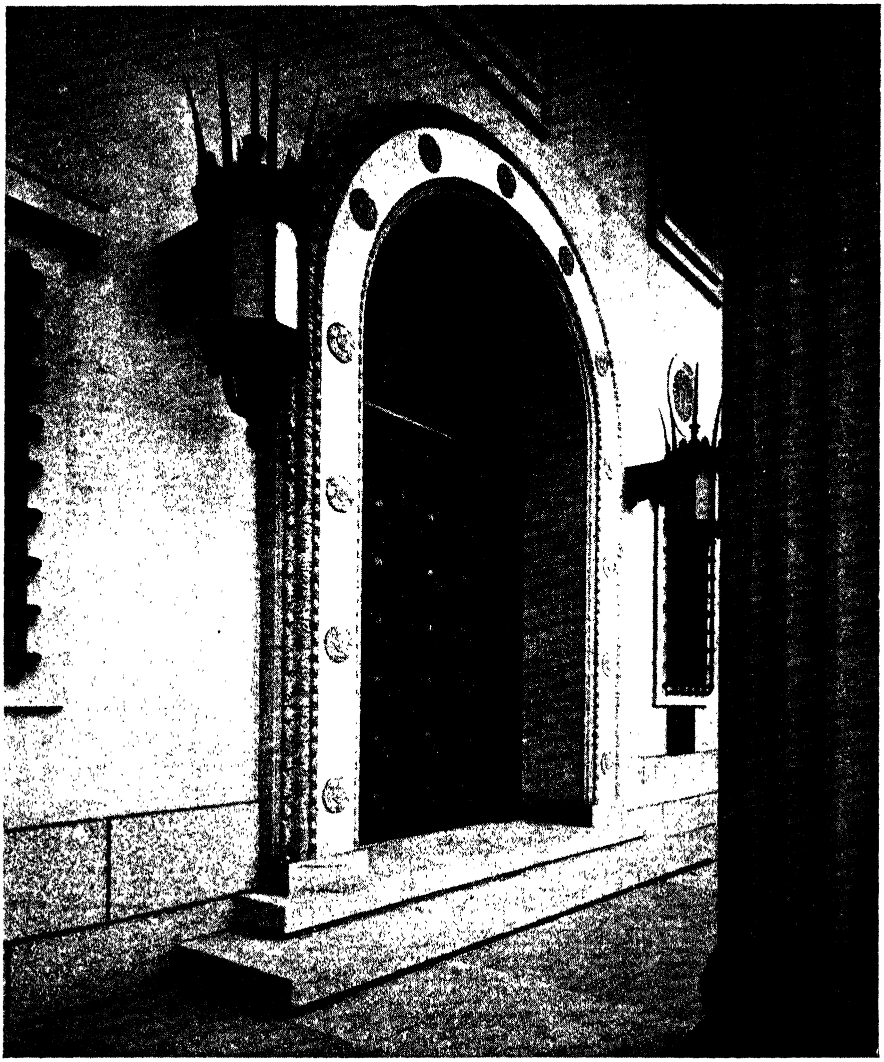


Fig. 6c.—Birmingham Municipal Bank—main entrance arch

Note that Portland stone is used. The door is of high-class enriched bronze metal. The base of the building is of axed Cornish granite. (*Architect: T. Cecil Howitt, F.R I.B.A.*)

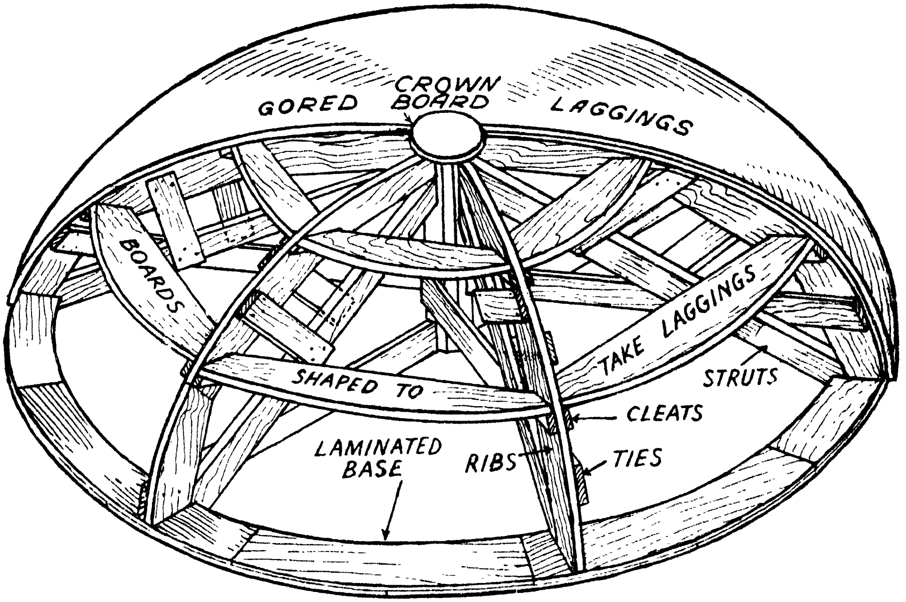


Fig. 7.—CENTRE FOR SEMI-ELLIPTICAL DOME

suitable for spans of about 6 ft. to 8 ft. The methods of supporting, and for easing by folding wedges, are shown.

Domes

The sketch in Fig. 7 shows the general construction of a semi-elliptical dome 10 ft. in diameter. The half-section in Fig. 8 shows the construction of one rib and the method of obtaining the shape of the template for the gored laggings. Step off a number of points as 1, 2, . . . 9, 10, as indicated on the section. Project these points down to the centre-line of the plan. If the laggings are to be cut from, say, 6-in. boards, set off this width half on each side of the centre-line and join to the point 10 (the centre of the dome). On the line *a a* step off 1, 2, . . . 9, 10, equal to those on the section. Mark off the width at 1 on *a a* equal to that at 1 on the plan ; make 2 equal to 2 on the plan, and so on. Cut the template at the point 9, which is the point where it meets the crown board. Cutting the template at the point 9 will give sufficient width for nailing, and the bevelled ends under the crown board give additional grip.

Plaster Centre for Niche Head

Fig. 9 shows a centre suitable for a niche head in gauged brickwork, semicircular in both plan and elevation. The space between the front and base boards is packed with shavings kept in place by a piece of

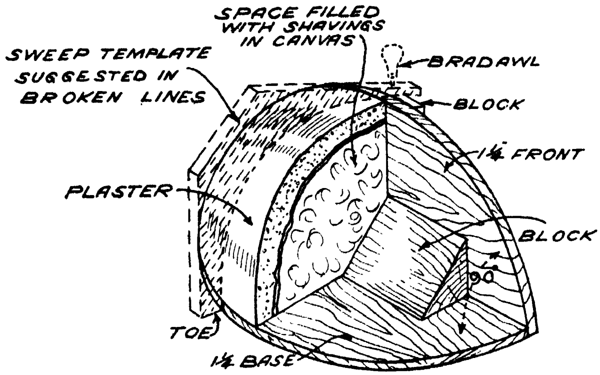


Fig. 9.—CENTRE FOR NICHE HEAD IN GAUGED BRICKWORK SEMICIRCULAR IN BOTH PLAN AND ELEVATION

canvas or expanded metal lathing, tacked to the boards. Plaster is then spread over, and a sweep template, cut to the quarter of a circle, is turned round the bradawl as a pivot, at the same time keeping the toe of the template tight against the base board.

Inverted Arches

The method of cutting the bed bricks for an inverted arch is shown in Fig. 10. The brickwork on either side is "raked" back until the horizontal centre line

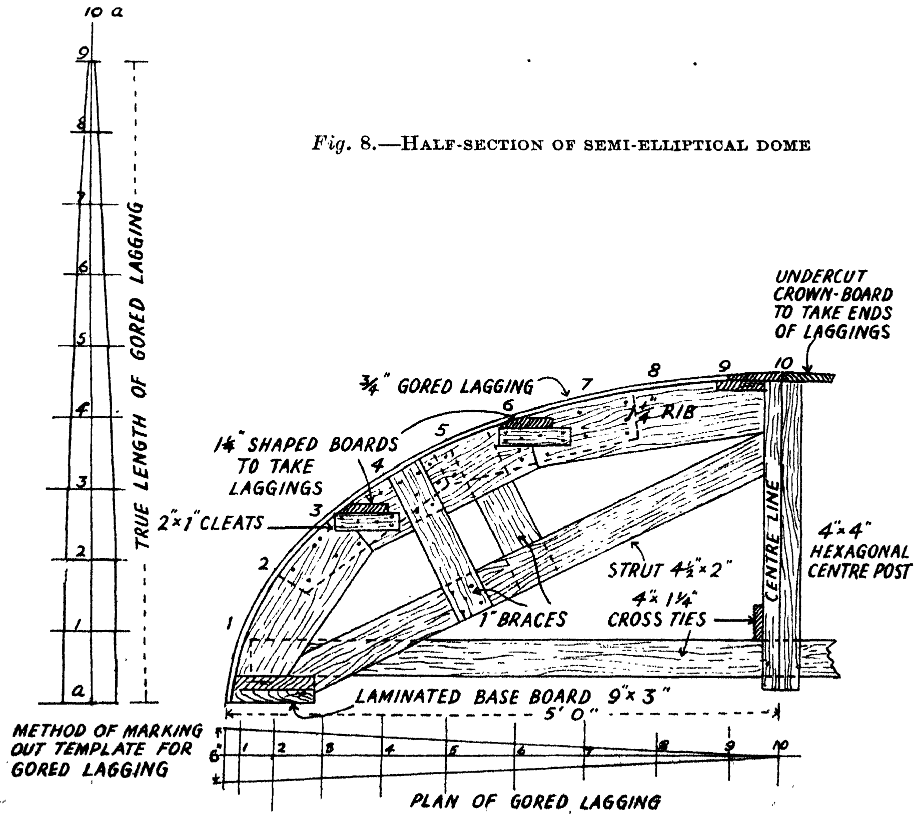


Fig. 8.—HALF-SECTION OF SEMI-ELLIPTICAL DOME

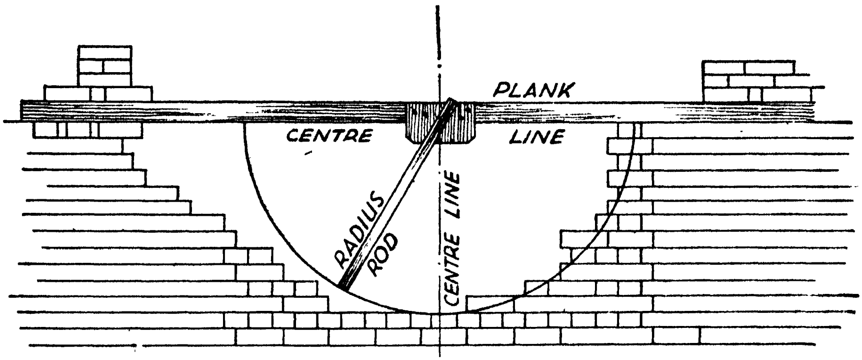


Fig. 10.—METHOD OF MARKING OUT INVERTED ARCHES

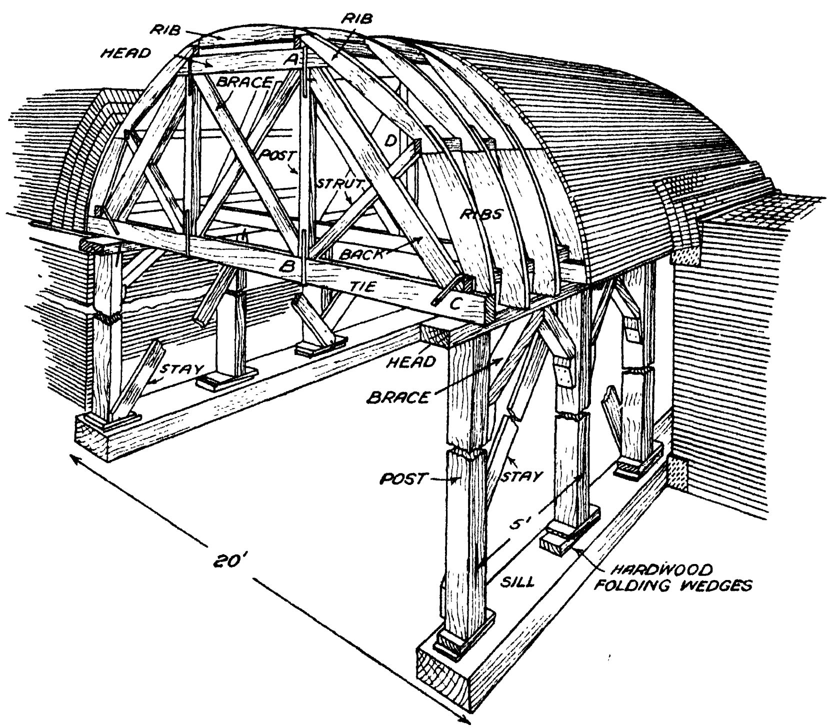


Fig. 11.—FRAMED CENTERING FOR BRICK BRIDGE OR TUNNEL
Details of the joints are shown in Fig. 11A.

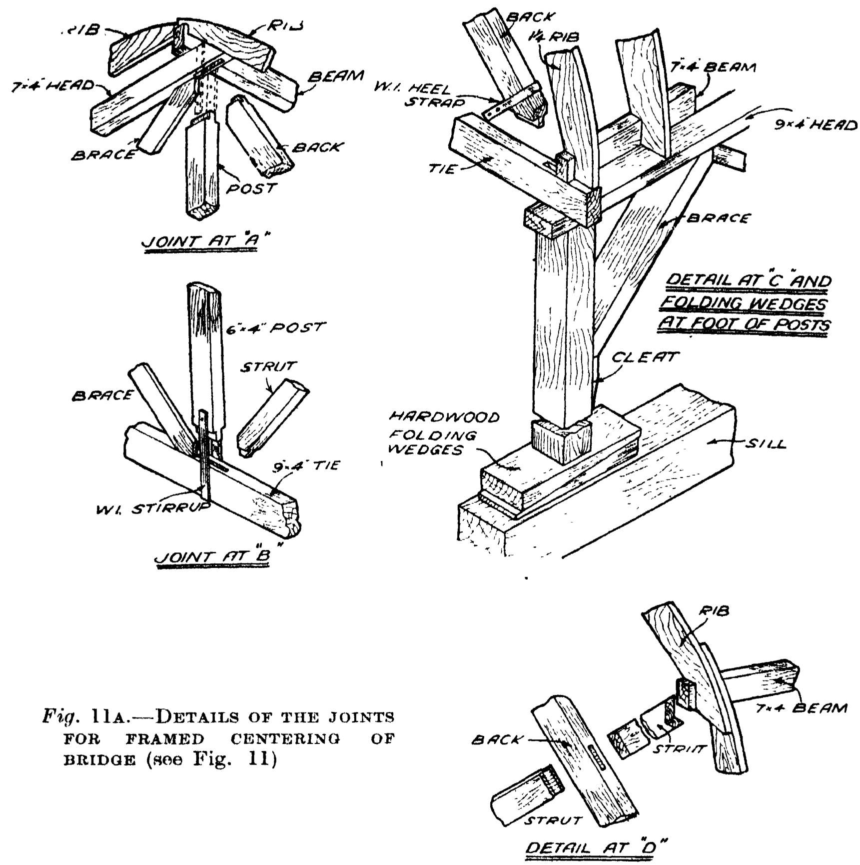


Fig. 11A.—Details of the joints for framed centering of bridge (see Fig. 11)

is reached. A plank is then laid across, weighted to keep it in position, and the vertical centre-line marked. As the bricks come within reach of the rod they are "scribed"—allowance being made for the thickness of the mortar joint, removed for cutting, and finally bedded and again tested.

Framed Centres

When centering is required for works such as brick tunnels or bridges, the ribs are spaced out on beams, which are in turn supported on frames spaced to suit the weight to be carried. The sketch in Fig. 11 shows the general construction of a framed centre. Fig. 11A gives details of the joints.

Vaulting

Fig. 12 shows a sketch of the centres for the cross-, wall, and diagonal ribs in position. These would have to be "racked" together to keep

Fig. 11B.—EDGE HILL TRAINING COLLEGE, ORMSKIRK

Showing arch detail at main entrance and the Corinthian columns, surmounted by the Lancashire County Council Coat of Arms. (*Architect : Stephen Wilkinson, F.R.I.B.A., A.F.C.*)

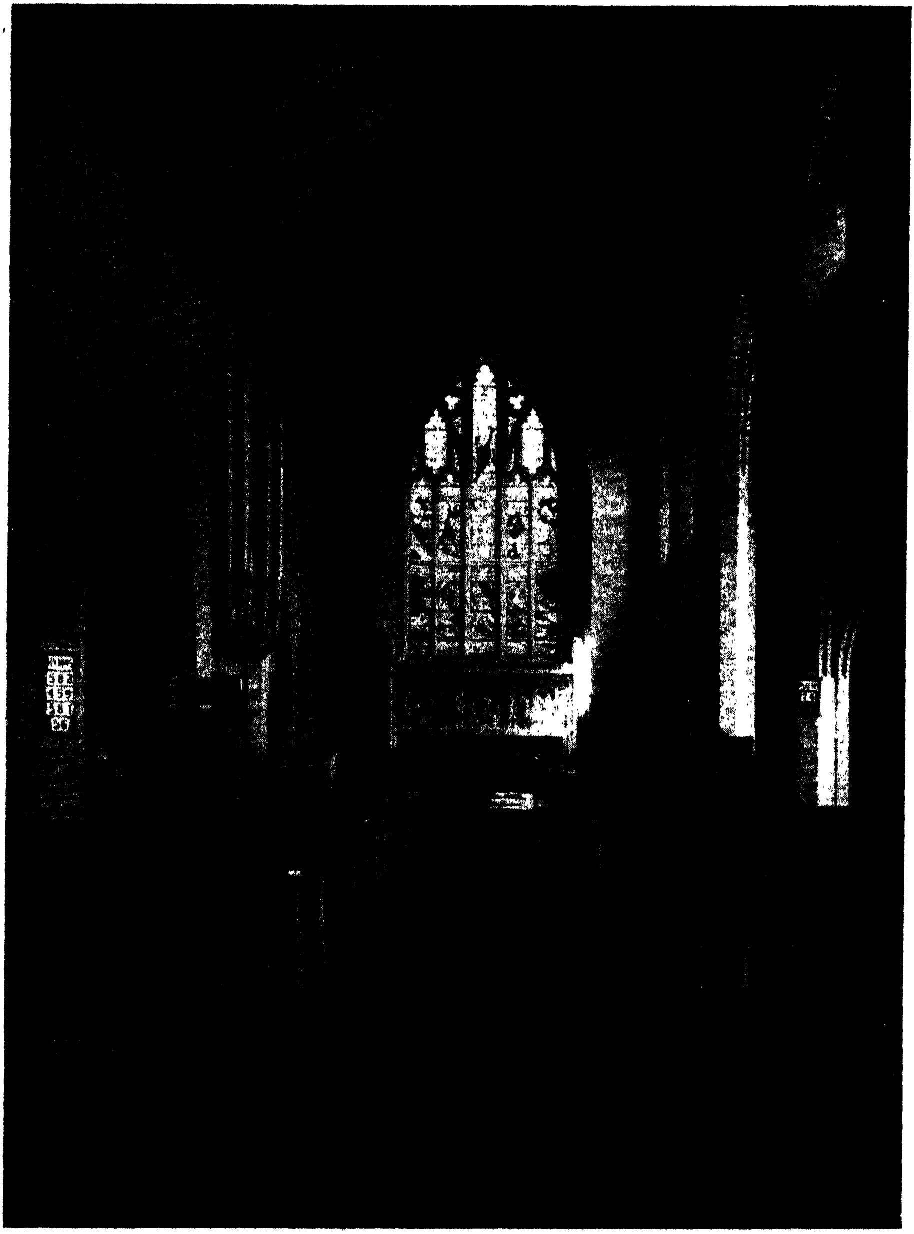


Fig. 11c.—Arches in the Church of the Good Shepherd, Romford

Walls and arches faced with sand-lime bricks. Windows are of Monks Park Bath stone. Roof is of British Columbian pine. (*Architects: J. E. Newberry, F.R.I.B.A., and C. W. Fowler, A.R.I.B.A.*)

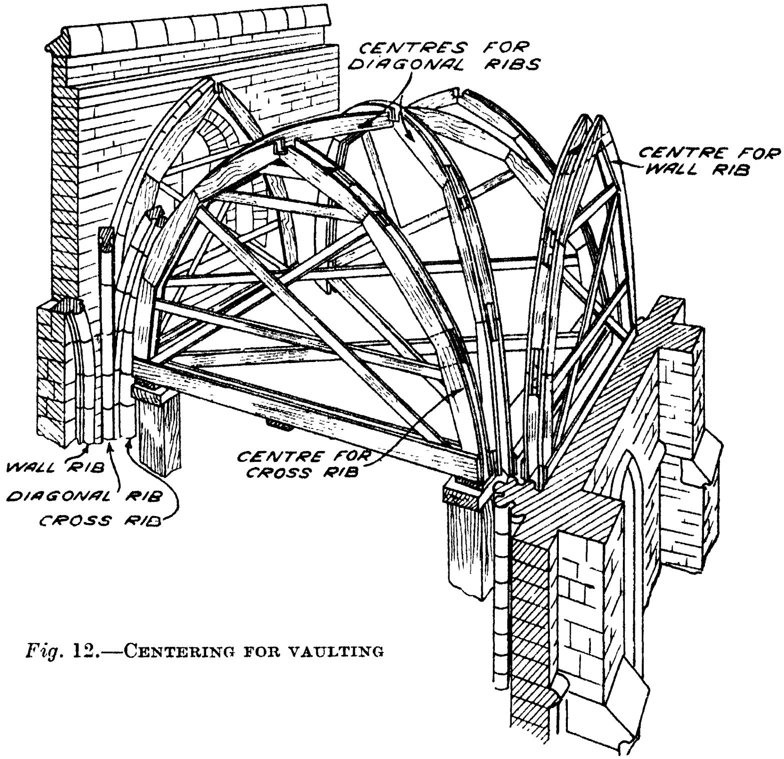


Fig. 12.—CENTERING FOR VAULTING

them upright; the racks are not shown in the sketch. In order that the diagonal ribs shall be straight on plan, the curves of the centres for the cross-rib and wall rib must be such that a given point on their curves shall be at the same level. For example, the heights of X′ (Fig. 12A) above the springing-line on the cross-rib and the wall rib must be the same, so that when the centres are erected horizontal lines from these points would intersect at Y on the diagonal rib. The same must be the case for any other point.

Intersecting Arches of Equal Height but Varying Span

The span and rise of the centre for the cross-rib are fixed, and the centre from which the curve is drawn determined as explained in Fig. 4. This centre may then be constructed.

The rise of the wall-rib centre is the same, but the span is different; therefore a curve must be found to satisfy the conditions with regard to the diagonal line being straight on plan. Divide half the span of the cross-rib centre into any number of equal parts 1, 2, . . . 8, 9, and draw ordinates parallel to the centre line; these ordinates meet the curve at

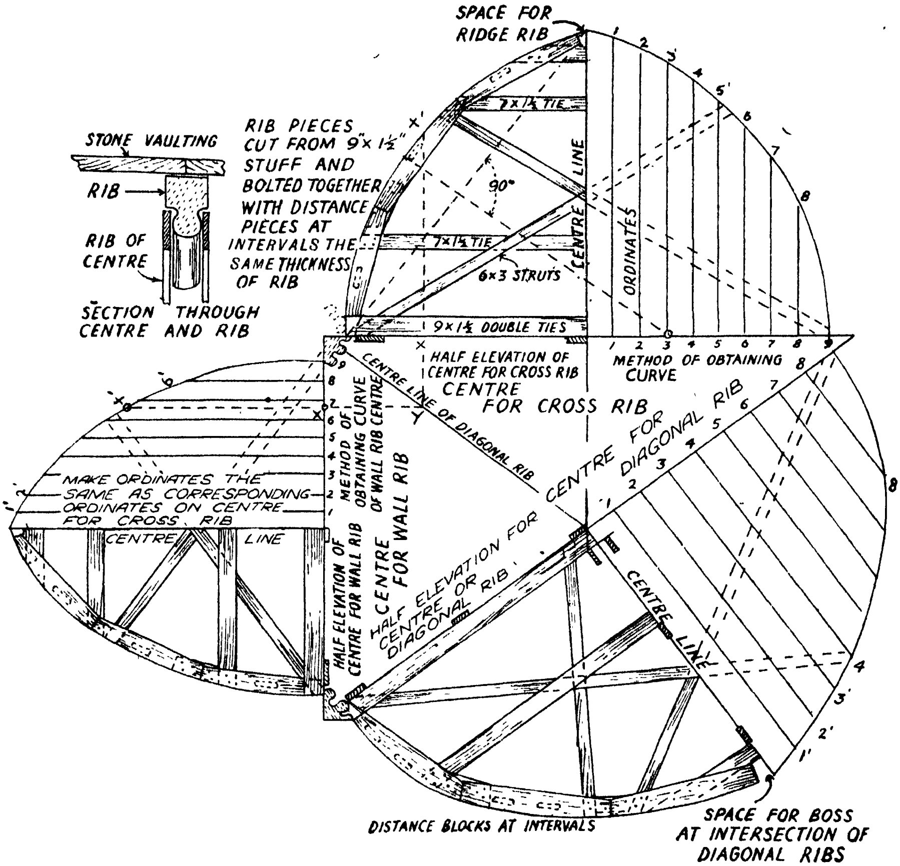


Fig. 12A.—Details for cross wall and diagonal centres for vaulting

1′, 2′, . . . 8′. Divide half the span for the wall rib into the same number of parts, and again draw ordinates. Mark off the ordinates on the wall-rib centre the same length as corresponding ordinates on the cross-rib centre, and with a thin lath draw the curve through the points. The same procedure will give the correct curvature for the diagonal-rib centres.

Severies or Panels

The spaces between adjacent ribs are filled in with slabs of stone; these are slightly arched, and an adjustable support is shown in Fig. 12C. Where the ribs are close together, as at the springing-line, one stone slab may bridge the span, but as the work rises and the span increases the

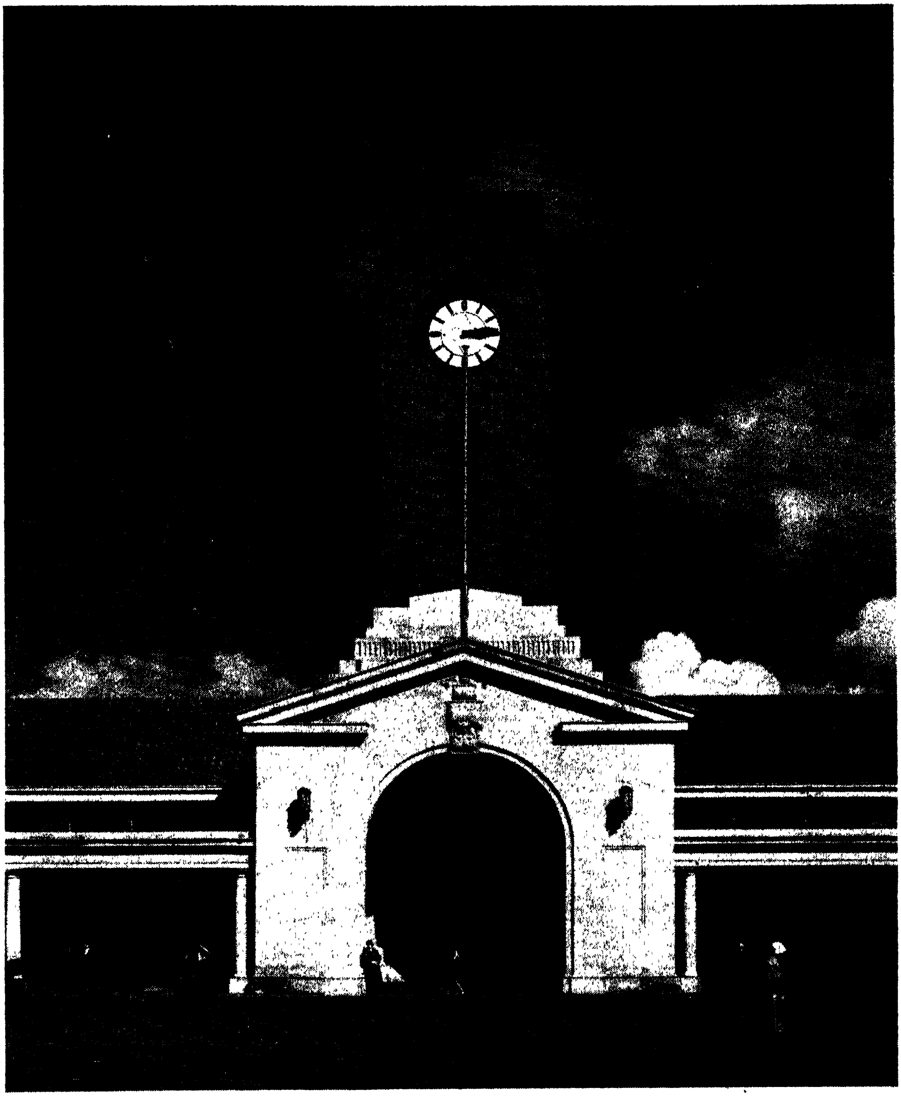


Fig. 12B.—SEACOMBE FERRY BUILDING, COUNTY BOROUGH OF WALLASEY
The entrance arch of Portland stone. The clock tower is carried out in a graded colouring of rustic brick. (*Architect : L. St. G. Wilkinson, M.Sc., M.Inst.C.E.*)

adjustable centres are laid between the ribs (the iron nib resting on the top) and the slabs bedded. The centres are then withdrawn and moved up to support the next course of slabs. The iron nibs should equal

approximately the thickness of the bed joint.

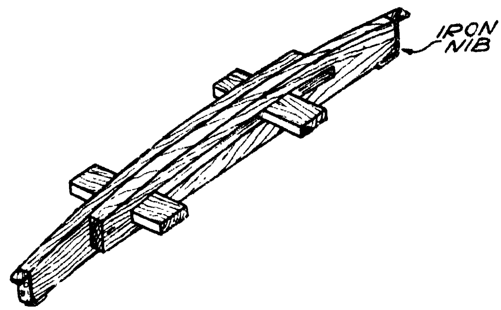


Fig. 12C.—ADJUSTABLE CURVED TEMPORARY CENTRE FOR SEVERIES BETWEEN RIBS OF VAULTING

Easing Centres

When any arched structure is finished, the centres should be slightly eased to allow the work to "bed down" firmly. The folding wedges, as shown in Figs. 6 and 11, are usually employed, but Fig. 13 shows another type which gives finer adjustment.

The maximum vertical drop which can be obtained by stepped folding wedges is small, but well suited for heavy loads. It is advisable to grease folding wedges of any kind, but especially stepped wedges, which are more liable to hang back when eased and then slip suddenly, tending to jar the work. The sand piston (Fig. 14) is another kind of support for heavy work. A turned hardwood block fits into a hollow iron cylinder partly filled with fine sand. Small holes round the sides of the iron cylinder are fitted with plugs, which when withdrawn allow the sand to escape and the turned wood block to settle down into the cylinder. For repair work, centres may have to be placed under arches already built, to give temporary support, and screw-jacks will be preferable to folding wedges: they give a steadier lift. Care must be taken when pulling on the tommy-bar that the jack is not thrown off the plumb, thus causing eccentric loading.

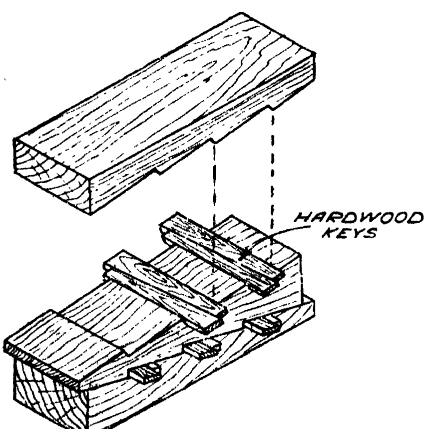


Fig. 13.—STEPPED FOLDING WEDGES

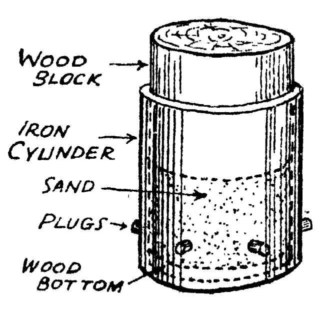


Fig. 14.—THE SAND PISTON—ANOTHER TYPE OF SUPPORT FOR HEAVY WORK

Chapter VIII

TEMPORARY TIMBERING FOR TRENCH EXCAVATION

UNDER this heading would be included all timber work necessary to support the sides of trenches.

Shallow Trenches

Shallow trenches, say 2 ft. in depth, suitable for the footings of small house property, will seldom require to have their sides supported by timber. If the foundation concrete is cast within a reasonable time of the trench being opened it will give the necessary support. See Fig. 1.

Fig. 2 shows timbering for a trench in moderately firm ground. The struts of all trenches should be at least 6 ft. apart so that workmen have the necessary working room. In moderately firm ground, apart from the dangers due to vibration caused by heavy traffic, the work of excavation should be fairly straightforward, but loose sand or waterlogged soils may offer difficulties.

Pressure on Timbers

According to the nature of the soil, so the pressure on the revetting materials varies. In other words "the angle of repose" for different soils affects the pressure on the retaining timbers. A trench in firm ground will, at least when first cut, throw little pressure on the timbers, but if the trench be kept open for any length of time it will soon begin to crumble, and lumps will break away unless it is timbered.

Ordinary Soil

The line AB in Fig. 3 might be taken to represent "the angle of repose" for ordinary soil, i.e. if a heap of the soil were thrown up, the surface would lie at that angle. The wedge-shaped portion marked A would therefore exert pressure against the timber.

Loose Sand Soil

Suppose the soil to be loose sand, line BC might be the angle of repose, and the combined pressure of the wedges A and B would be thrown against the timbers.

Wet Sand

Again, suppose the sand to be wet, and CD the angle of repose, a little

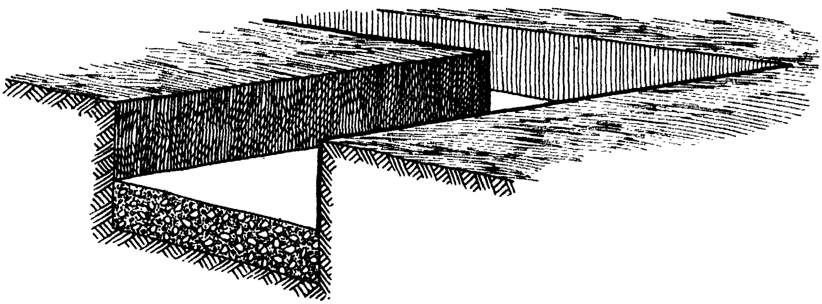


Fig. 1.—SHALLOW TRENCHES, SUITABLE FOR THE FOOTINGS OF SMALL HOUSE PROPERTY SELDOM REQUIRE TIMBER SUPPORTS

If the foundation concrete is cast within a reasonable time of the trench being opened, it will give the necessary support.

more pressure is added by the wedge C. The nearer the soil approaches to a liquid condition the greater will the pressure become until it is governed by the laws for liquids. The formation of the ground and the time for which the trench must be left open will govern the amount of support necessary.

TYPES OF TIMBERING

Trench for Drains

Fig. 4 shows a trench such as might be required for a drain, and the ground is assumed to be of a loose nature. As the trench is cut, horizontal boards are laid against the sides with temporary struts wedging them apart. Temporary struts and "poling boards" should be placed in such a position that they will not interfere with the final pieces being fixed. When the depth is reached upright pieces (poling boards) are placed as shown with a strut at top and bottom.

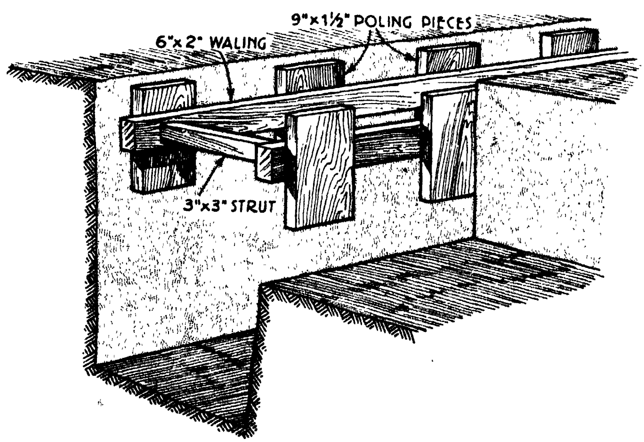


Fig. 2.—TIMBERING FOR A TRENCH IN MODERATELY FIRM GROUND

Trench for Sewer

A deeper trench such as might be

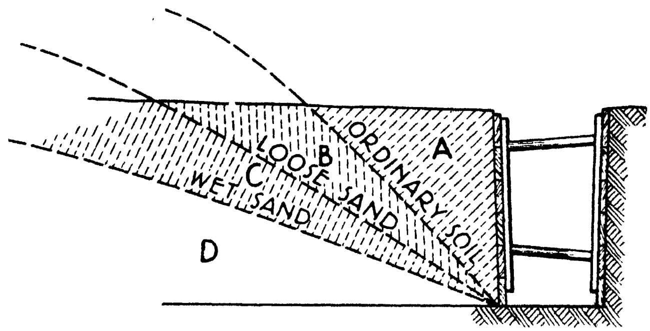


Fig. 3.—THE NATURE OF THE SOIL AFFECTS THE PRESSURE ON THE RETAINING TIMBERS

The nearer the soil approaches to a liquid condition the greater will the pressure become.

required for a sewer is shown in Fig. 5, and again the ground is loose and requires close boarding. As the ground is excavated temporary struts keep the sides from caving in and these are replaced as soon as possible by "sheeting" and horizontal battens (walings).

The "spoil" from a trench can be thrown clear of the edge from a depth of 5 or 6 feet, but for lower levels some arrangement must be provided to enable this to be done. A platform (as suggested in Fig. 5) is provided by laying boards on the temporary struts of the top section. The earth from the lower part is thrown on the platform, and from there to the surface. If the trench has to be still deeper it is carried down by successive stages in the same manner.

Trench for Waterlogged Soil

Fig. 6 illustrates a method of dealing with loose sand or waterlogged soil. The edges of the boards are shaped to fit (Fig. 6A) and the points cut on the slope. As the trench is excavated the boards are driven down

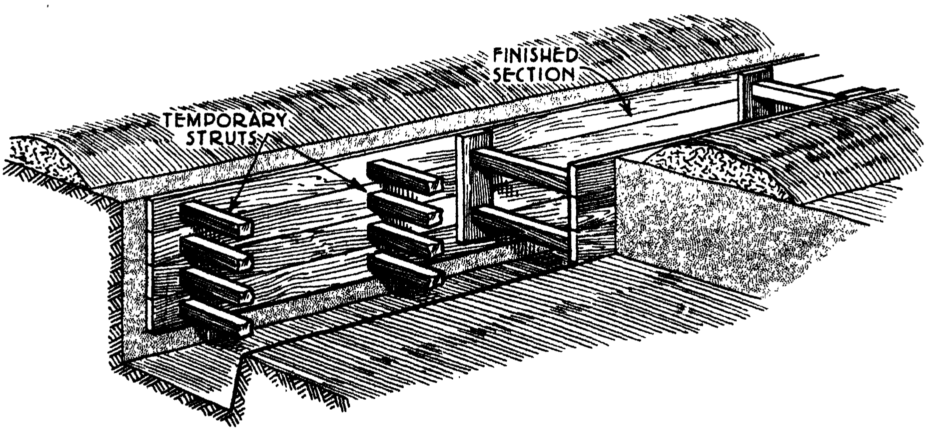


Fig. 4.—TIMBERING FOR A TRENCH FOR A DRAIN IN GROUND OF A LOOSE NATURE

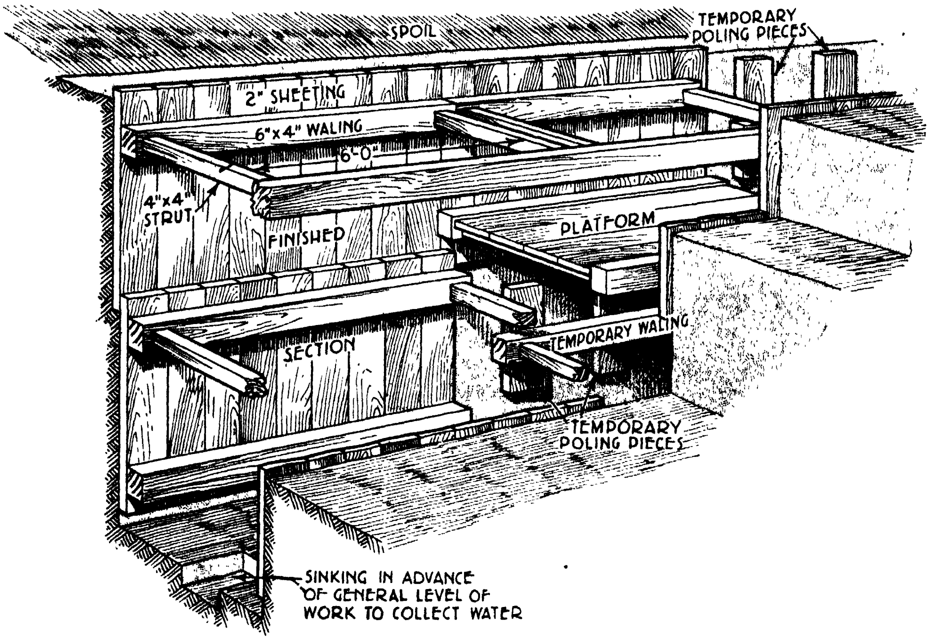


Fig. 5.—TIMBERING FOR A DEEPER TRENCH, SUCH AS MIGHT BE REQUIRED FOR A SEWER

in advance of the digging and the sloping points tend to keep the joints close. The boards being driven down in advance of the digging prevents the loose sand or waterlogged soil from " boiling up " from the bottom of the trench and thus causing voids behind the " sheeting."

Depth Governs Pressure

If the ground is very wet, and the pressure against the timbers almost approaching the laws governing liquids, then as the trench gets deeper the sizes of " walings " must be increased. The timbering for deep trenches should be calculated to meet the increase of pressure due to the greater depth.

In Fig. 7 the rectangle 6 ft. by 5 ft. shows the area supported by a " waling " 10 ft. from the surface. That part of " waling " between the struts is really a beam subjected to a uniformly distributed load due to the pressure of the earth.

How to Calculate Pressure

Assume the earth to be waterlogged and practically acting as a liquid in regard to pressure. At 10 ft. below the surface the pressure per square inch would be 4·34 lb. The pressure over the area 5 ft. by 6 ft.

$$= 5 \text{ ft.} \times 6 \text{ ft.} \times 144 \text{ (in. per sq. ft.)} \times 4{\cdot}34 \text{ lb.}$$
$$= 18749 \text{ lb.} = 167{\cdot}4 \text{ cwt.}$$

Formula for Finding Breaking Weight of Uniformly Loaded Beam

The breaking weight of a beam uniformly loaded may be found by the formula $BW = \frac{Cbd^2}{\frac{1}{2}L}$ where BW = breaking weight in cwt., C = constant (for yellow deal this constant is 4), b = breadth of beam in inches, d = depth of beam in inches, L = span of beam in feet.

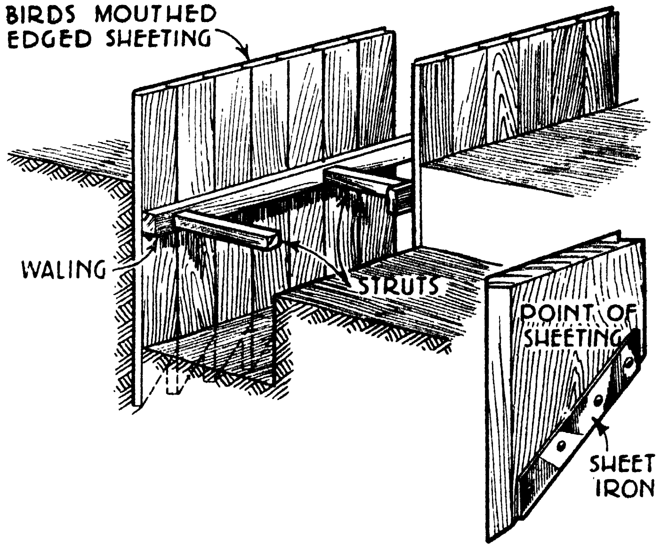


Fig. 6.—SUGGESTED METHOD OF DEALING WITH LOOSE SAND OR WATER-LOGGED SOIL, USING BIRDS MOUTHED EDGED SHEETING WITH POINTED ENDS

Fig. 6A. — SHOWING HOW THE POINTS OF THE BOARDS ARE CUT ON THE SLOPE

A beam which would break under a distributed load of 167·4 cwt. would be useless ; therefore it is necessary to allow a "factor of safety." For timber a "factor of safety" of 4 is usual. So a beam capable of taking a load of 167·4 cwt. × 4 (factor of safety) is required, say 670 cwt. Try how a "waling" 6 in. by 6 in. would do.

$$BW = \frac{Cbd^2}{\frac{1}{2}L},\ BW = \frac{4 \times 6 \times 36}{3} = 288 \text{ cwt.}$$

This is too small. Try an 8 in. by 8 in.

$$BW = \frac{4 \times 8 \times 64}{3} = 682{\cdot}6 \text{ cwt.}$$

Therefore a waling 8 in. by 8 in. is required at 10 ft. below the surface level.

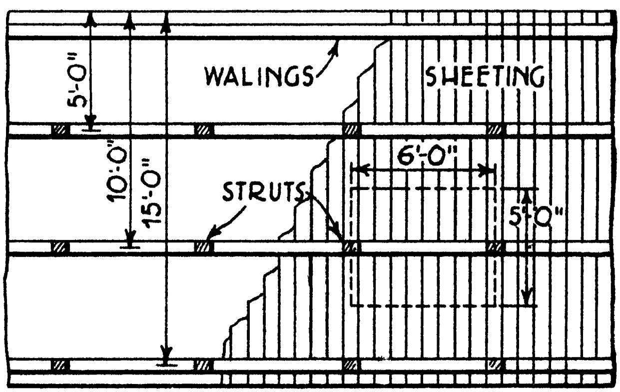


Fig. 7.—THE TIMBERING FOR DEEP TRENCHES SHOULD BE CALCULATED TO MEET THE INCREASE OF PRESSURE DUE TO THE GREATER DEPTH

The rectangle 6 ft. × 5 ft. in the above diagram shows the area supported by a waling 10 ft. from the surface.

Hints on Timbering

In good solid ground, such as chalk, trenches may be carried to a considerable depth without timbering, but it is false economy to take risks. Speaking generally, gravel is a very treacherous material, and although it may appear to be safe, sudden landslides into the trench may be expected. In deep trenches this has been known to lead to fatal accidents. Clay, when in a fairly dry condition, may prove to be self-supporting for a reasonable time, and even deep trenches are sometimes made with a very small amount of timbering provided the foreman in charge is aware of possibilities of trouble and has at hand the material and labour required for dealing with any emergency. Where from any cause clay becomes wet it is a very treacherous material, and may collapse badly and suddenly. A collapse of the clay is not, however, quite so serious, as far as the workmen are concerned, as a fall of gravel, because gravel will bury a man completely, whereas clay generally falls in masses, leaving some breathing-space. Sandy formations may be reasonably stable or the reverse.

In some formations, the sides of a trench which would stand without support indefinitely in a dry condition may collapse immediately, owing to the presence of water. Made ground is always treacherous, and should not be trusted to support itself. Local experience is valuable in trench work and an experienced local foreman will generally be able to judge how much support is required, but he should not be allowed to take unnecessary risks.

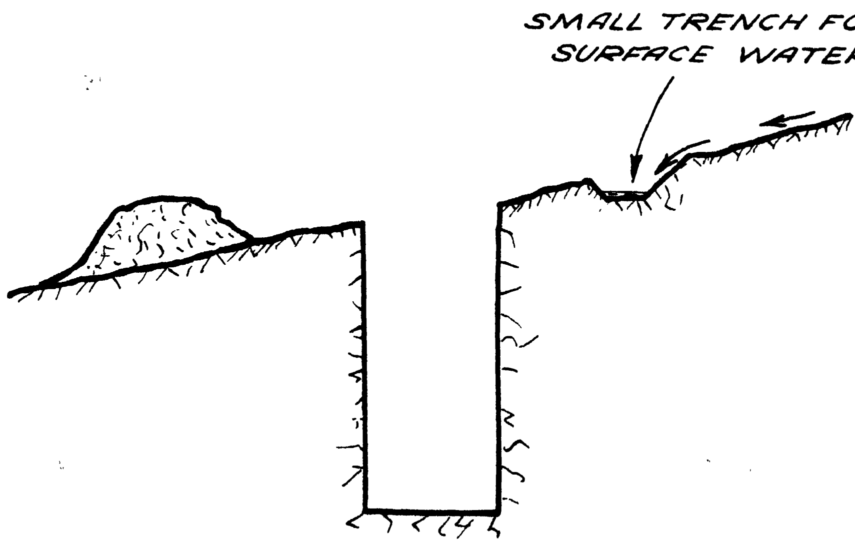


Fig. 8.—DIVERSION OF SURFACE WATER FROM TRENCH

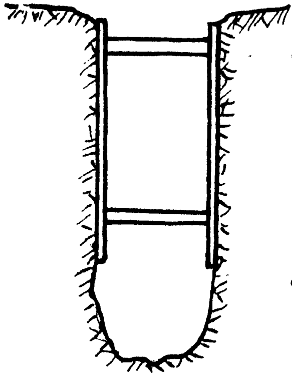


Fig. 9 (*above*).—SIMPLE TIMBERING WITH PINCHERS

The sides of a trench may be supported at any weak point by means of a pair of vertical planks, called "pinchers," about 9 in. by 3 in. in section, fixed on opposite sides of the trench, and held in position by struts, which must be firmly driven.

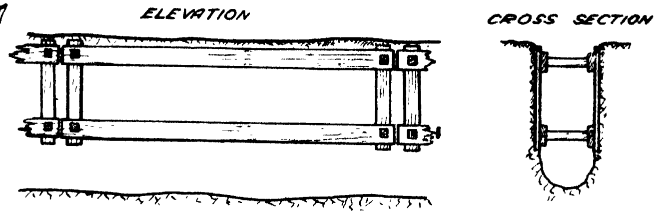


Fig. 10.—SIMPLE TIMBERING IN GOOD GROUND

Timbering for trench made in fairly solid ground to a depth of not more than 5 or 6 ft.

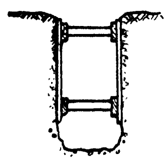


Fig. 11.—TIMBERING IN BAD GROUND

If the ground is of such a nature that it is likely to require extra support, the polling boards should be set against the side of the trench at the start, without any recess.

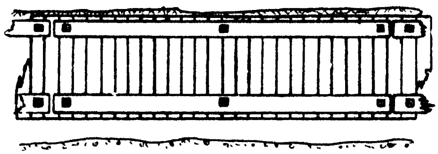


Fig. 14.—DEALING WITH SANDY SOIL.

If the conditions require close timbering, the walling should be 9 in. by 3 in. in section, the polling boards $1\frac{1}{4}$ in. thick, and struts 6 ft. apart.

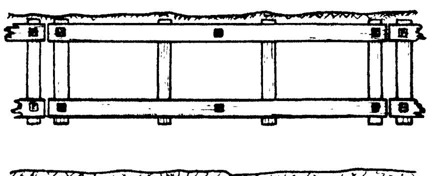
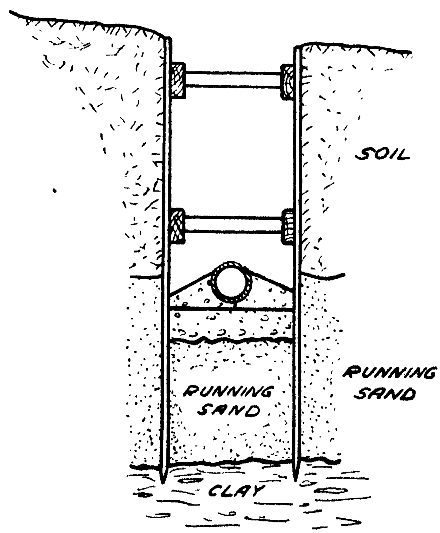


Fig. 12 (*above*).—SIMPLE TIMBERING IN GOOD GROUND

Additional polling boards can be inserted by driving them behind the walings, and additional struts can be fixed if this is found to be necessary.

Fig. 13 (*right*).—DEALING WITH SANDY SOIL

Showing how runners can generally be driven through a shallow stratum, to make a fairly tight joint with a solid stratum below.



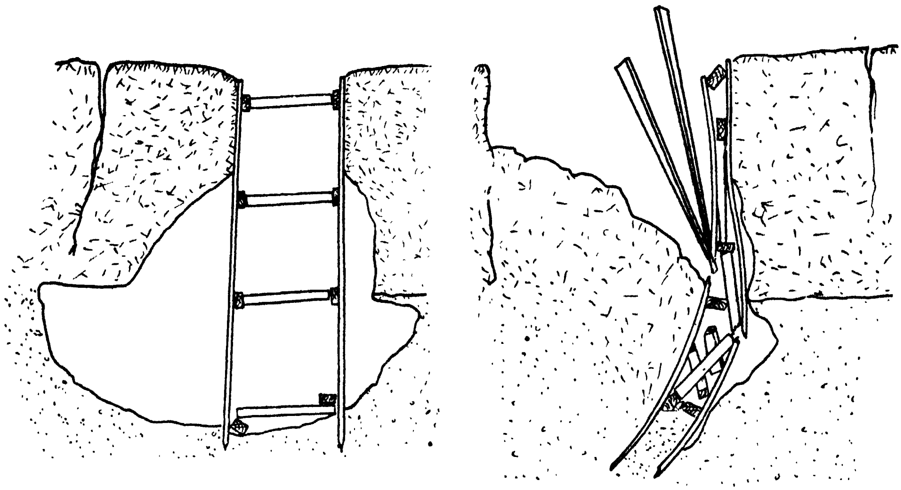


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Fig. 15.—Showing the effect of the flowing in of running sand

To prevent this, the runners must be fixed close together so as to make tight joints. (See Fig. 14.)

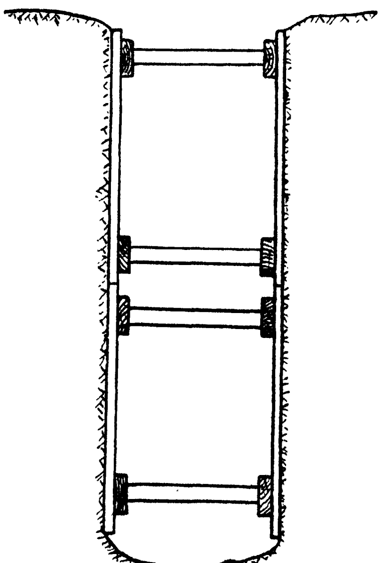

Fig. 16.—Timbering in good ground

It is sometimes possible to excavate 4 ft. below the first frame, and to put in two sets of walings for the lower frame without diminishing the width of the trench.

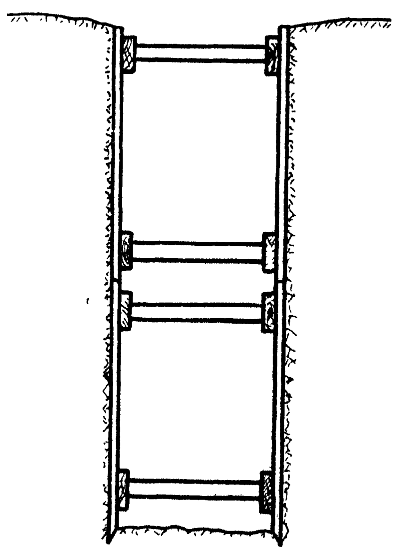

Fig. 17.—Timbering in bad ground

If the width of the trench is not to be diminished, the polling boards of the first frame must be driven down as the ground below is taken out, and other polling boards must be put in to replace them.

Trenches have to be supported by timber to the extent which the conditions may require, in order to prevent collapse. It is unwise to economise in this respect. In the event of the sides falling in, the earth has to be removed from the trenches, and the timbering is then far more difficult. In deep trenches there is the risk of injury to workmen. The chances of injury to the work which has been done in the trench, or which has been partly done, are great, and the cost of setting such injury right is considerable. Very few soils can be trusted to stand entirely unsupported even for a depth of 5 ft., and in some cases support may be required for shallower depths.

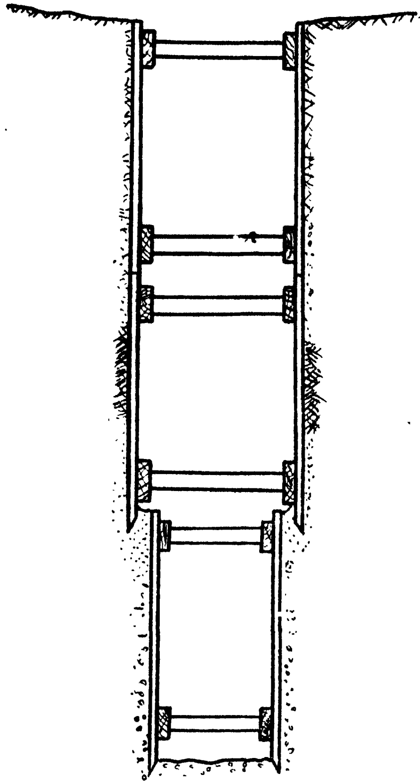

Fig. 18.—WHEN FRAMES ARE REQUIRED BELOW A DEPTH OF 12 FT., THE WIDTH OF THE TRENCH MUST BE DIMINISHED BY ANOTHER FRAME OF POLLING BOARD FIXED AS SHOWN ABOVE

The amount of the support required will depend entirely upon the nature of the ground. One great safeguard is to have plenty of timber at hand, so that in case of any weakness becoming apparent the sides of the trench can be supported immediately. With such material available and ready to hand, it is sometimes possible to do work which would be absolutely unsafe if the means of dealing with sudden emergencies were not available.

The first principle of timbering is that any timber work put in should be of such a nature that it can be made more secure rapidly by means of additional timber. It is also necessary, in deep work, that the trench should be of such width that proper space will remain for working after all timbering has been fixed, allowing for the contraction of the lower part of the trench.

Sometimes running sand is encountered even at shallow depths; in this event the very greatest care is required at the outset. No excavation should be made in the quicksand until very definite precautions have been taken. Very serious trouble is sometimes caused by the pumping or removal of running sand; cavities are formed behind the timbering, and subsidences of the ground surface, and possibly of adjoining buildings, may occur, and great trouble and expense may result.

Chapter IX

EXCAVATING MACHINERY

MECHANICAL excavators are now recognised as an essential part of the larger builder's equipment for use upon the construction of large buildings and housing estates. Building operations, of course, embody varying classes of work, and while the economy and efficiency of mechanical methods are well known, such economies would not result in many cases if it were necessary to apply a single-purpose machine separately to each of the various duties. The best application obviously is an all-purpose unit that can be converted to suit each class of work. Manufacturers of excavating machinery, in designing their machines, try to make one attachment serve as many purposes as possible, so that the changing of the type of equipment to suit the particular work in hand can be done without the expense of providing additional attachments ; this has been achieved to a large extent in some of the smaller sizes of equipment.

The most popular and generally used machines are the small excavators mounted on caterpillar tracks with working weights of approximately 8 to 17 tons and fitted with buckets of $\frac{3}{8}$, $\frac{1}{2}$, and $\frac{5}{8}$ cu. yd. capacity.

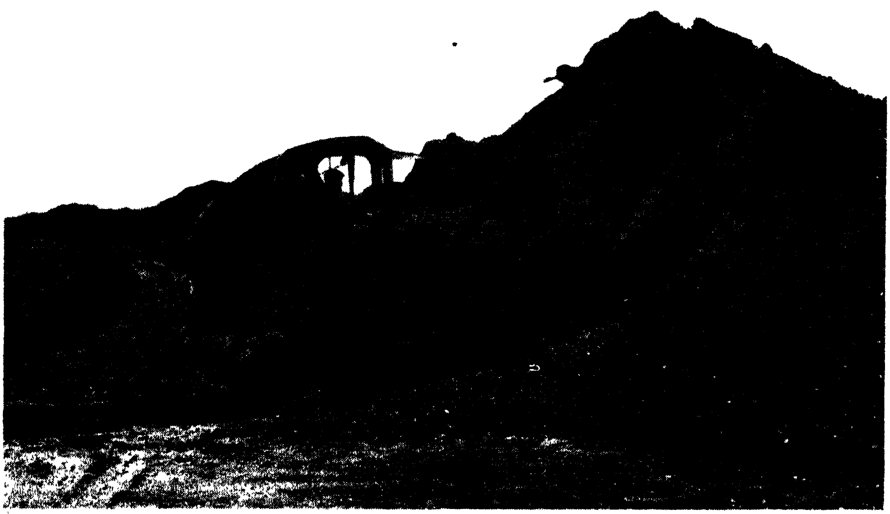

Fig. 1.—EXCAVATOR EQUIPMENT WORKING AS SHOVEL OR NAVVY
(*Ransomes & Rapier, Ltd.*)

Uses of Excavators

The following are the uses to which the universal type of builder's excavator can be put:

(1) Excavating cellars and taking out the necessary material for foundations upon large building jobs,

(2) for clearing and levelling ground upon housing estates,

(3) making necessary road excavations,

(4) excavating and filling in trenches for pipelines.

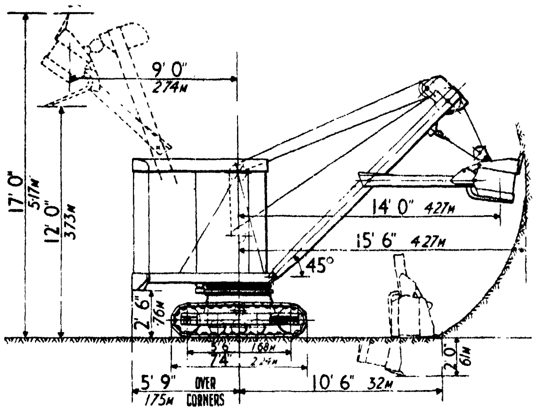

Fig. 2.—A TYPICAL 8-CU. FT. CAPACITY EXCAVATOR USING SHOVEL ATTACHMENT, SHOWING DIMENSIONS

(*Thomas Smith & Sons* (*Rodley*), *Ltd.*)

(5) They may be employed as cranes, usually with specially long light booms, for erecting structural work, and for lifting and lowering skips, etc., into foundations, trenches, etc.

(6) They are also fitted with pile-driving equipment.

From the above it will be seen that they have in fact " 101 uses," and

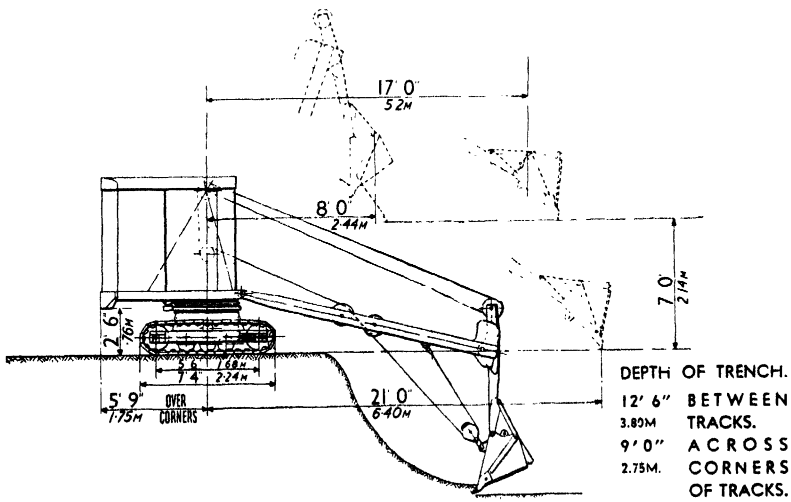

Fig. 3.—8-CU. FT. CAPACITY EXCAVATOR USING BACK-ACTING TRENCHER ATTACHMENT

Showing dimensions. Note the jib is the same as that used for the navvy shovel (Fig. 2). The same bucket is also used as a skimmer (see Fig. 5).

(*Thomas Smith & Sons* (*Rodley*), *Ltd.*)

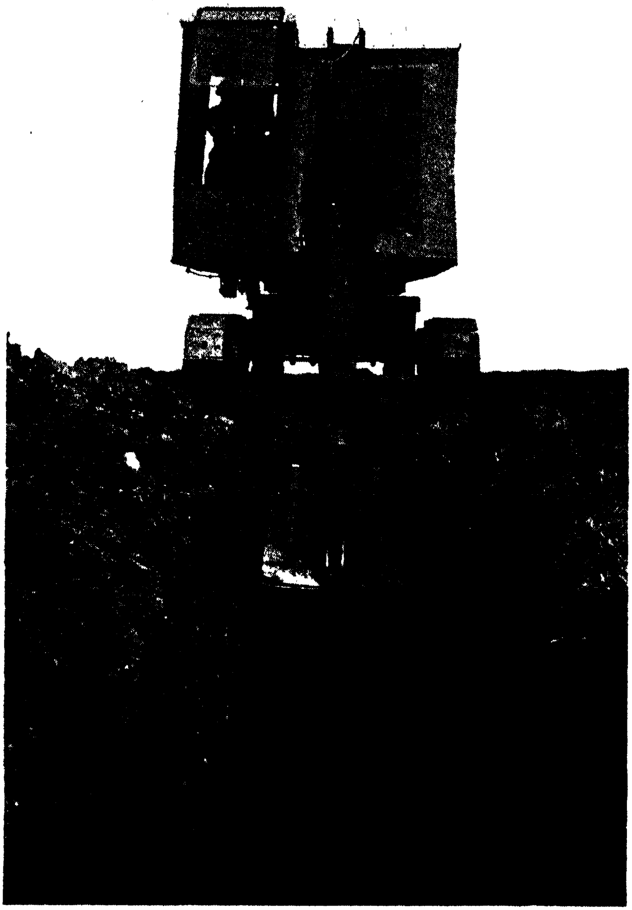

Fig. 4.—Excavating trench with back-acting trencher (*Ransomes & Rapier, Ltd.*)

upon large building and construction jobs they need never be idle while the builder has work in hand.

These universal type excavators are quickly convertible for use with the following digging equipments :

Shovels

The shovel equipment, or navvy shovel, is used in general excavation, large clearance and levelling jobs where the machine works at a bank and finds its best application where the depth is say 6 ft. or more.

Drag Shovels or Back-acting Trenchers

The drag shovel or back-acting trencher equipment, as its name implies, is put to the work of excavating for cellars and foundations, and excavating trenches which are part of building development for water, sewerage, or gas mains, and drainage purposes. Depths up to about 16 ft. are possible with these universal excavators and from 1 to 3 ft. wide in a single cut, although trenches or cuttings up to any required width can be made by increasing the number of cuts across the trench.

Skimmers

For the removal of shallower layers, general clearance and levelling jobs, and taking out material preparatory to putting in the necessary

material for new roads, the skimmer scoop is usually employed. The skimmer scoop has a more or less horizontal digging action and is ideal where the excavation is from 6 in. to about 2 ft. in depth. At the end of each stroke, the main boom and bucket are hoisted in order to discharge into lorries or on to banks.

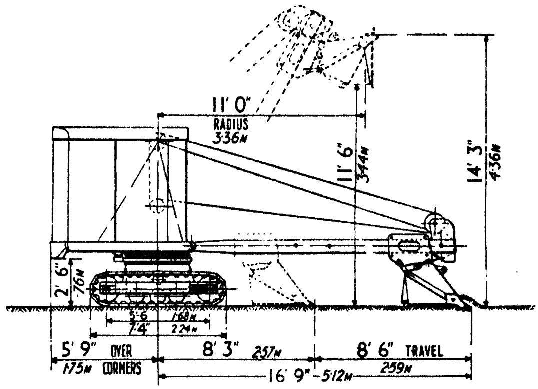

Fig. 5.—8-CU. FT. CAPACITY SKIMMER SCOOP

Showing dimensions. Note that the jib is the same as for navvy shovel (Fig. 2) and the bucket is the same as for trencher (Fig. 3). The height of bucket when dumping is indicated. (*Thomas Smith & Sons (Rodley), Ltd.*)

Cranes

There is, of course, much lifting to be done in connection with building, not only of various materials but of articles of equipment, and such duties as the lowering of pipes into trenches. For these the excavator is converted to a crane.

Similarly, the equipment can be converted to a grabbing crane for handling loose material from stock piles, and for excavation of a confined

Fig. 6.—CUTTING ROAD WITH SKIMMER SCOOP—FOUR-PURPOSE EXCAVATOR

Showing the machine discharging earth into lorry. (*Ransomes & Rapier, Ltd.*)

Fig. 7.—Rapier four-purpose equipment arranged as 1-ton crane

The handle of bucket (shown in Fig. 6) is used as an extension of the jib. (*Ransomes & Rapier, Ltd.*)

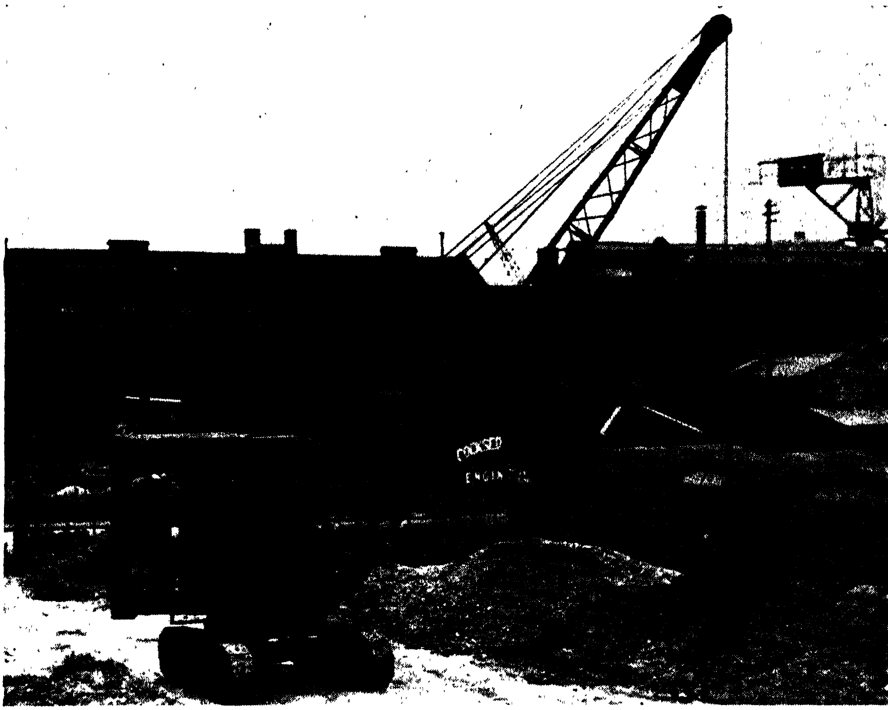

Fig. 8.—Equipment working with grab bucket

A long lattice-type jib has been fitted to the standard four-purpose excavator and with this the machine can be used as grab, as shown, or dragline (see Fig. 9), or again as a crane with a longer range than is given with the ordinary equipment as illustrated in Fig. 7. (*Ransomes & Rapier, Ltd.*)

area, such as sinkings or deep foundations, headers for sewerage or water channels, etc., beyond the working depth of the drag shovel or back trencher equipment.

For conversion to a crane or grabbing crane, it is usual to fit a long lattice-type jib in place of the short boom which is employed for the back-acting trencher and skimmer scoop if the length of the ordinary jib for crane duty is too short for the job in hand.

In two of the smaller sizes of Rapier excavator—the 5 cu. ft. and the $\frac{3}{8}$ cu. yd. bucket capacity types—lengthening of the jib is achieved by removing the bucket handle, as used for trencher and shovel, and fitting it to the end of the jib or boom. In these machines the forms of shovel, skimmer scoop, back-acting trencher, and crane are provided with a single set of parts. Conversion from one of these forms to another is effected merely by rearrangement of the same parts, no extras being required. The change-over can be made in the field and in less than an hour. The boom remains unaltered for each condition and no special

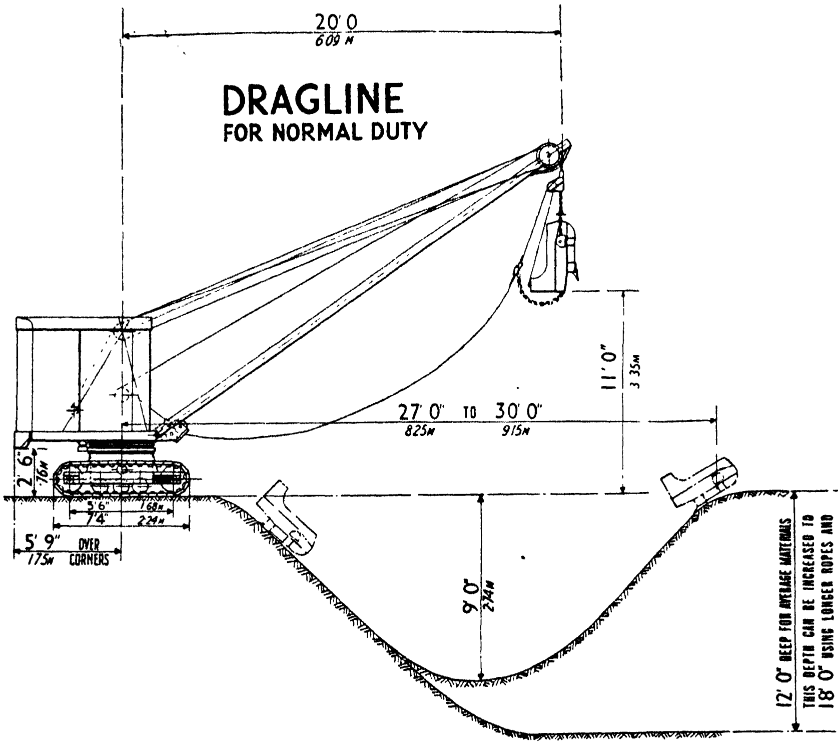

Fig. 9.—8-CU. FT. CAPACITY EXCAVATOR ARRANGED AS DRAGLINE FOR NORMAL DUTY

In this machine a channel-type jib is fixed, 25 ft. long. Note the dimensions of the cut. (*Thomas Smith & Sons* (*Rodley*), *Ltd.*)

tackle or lifting gear is required for changing over. If a crane with a longer range is required than is given with this four-purpose equipment, a lattice-type jib can be fitted.

Draglines

The dragline is employed for the excavation of pits or trenches which by their size, shape, or the condition of the ground call for a machine with a long reach. The fitting of a long jib to the machine and a dragline bucket are required. Considerable use is made of draglines for excavating waterlogged materials, constructing new draining ditches, and for cleaning out and widening existing channels or ditches and for working depths beyond the range of the drag-shovel equipment.

Pit Work

Quite apart from the actual building operations, all the foregoing equipments are used in sand and gravel pits, clay pits and similar undertakings, for obtaining the different materials required for building.

Power Unit

Excavators are available with either petrol, petrol-paraffin, or diesel engines. When first introduced, choice of petrol and diesel engines was about equally divided, but recently the diesel engine has practically replaced the petrol or petrol-paraffin engine.

Diesel engines of 33, 44, and 54 horse-power are fitted to the $\frac{3}{8}$, $\frac{1}{2}$, and $\frac{5}{8}$ cu. yd. sizes respectively. The diesel oil consumptions average about $\frac{3}{4}$, 1, and $1\frac{1}{4}$ gallons of diesel oil per hour.

The working cost of these machines, including maintenance, are extremely low and outputs up to 500 or 600 cu. yds. per day are obtainable.

Using the Excavator

One man only, the operator, is required upon the machines. Because of their caterpillar mountings, they are extremely mobile, which enables

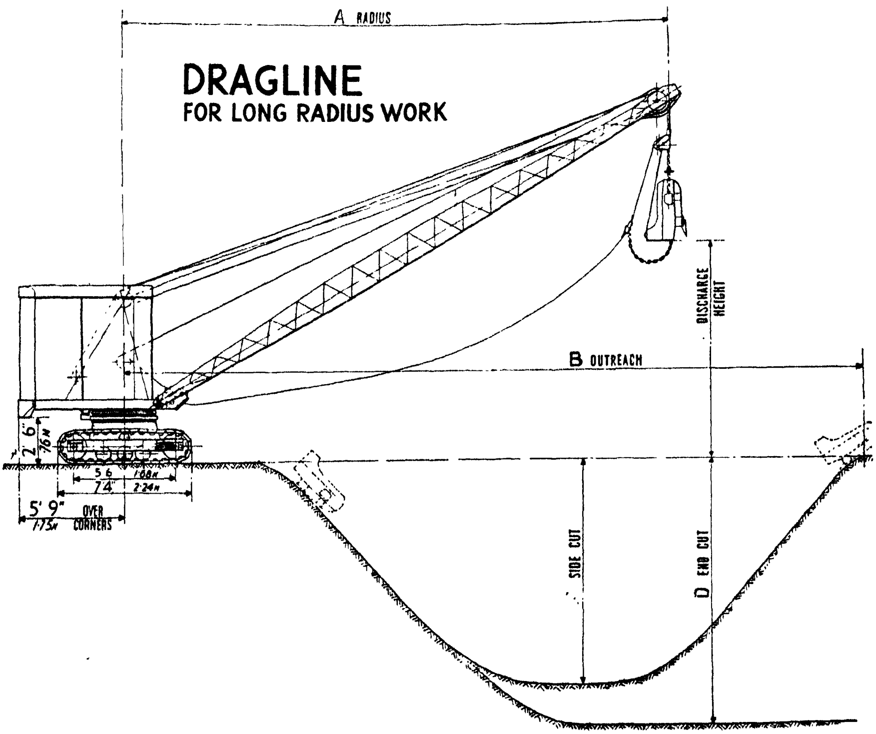

Fig. 10.—8-CU. FT. BUCKET CAPACITY DRAGLINE FOR LONG RADIUS WORK

This is the same machine as in Fig. 9 but fitted with a long jib. The discharging radius A is 26 ft.; outreach B, 36 ft.; discharge height, 15 ft.; digging depth, end cut, 16 ft.; digging depth, side cut, 12 ft. (*Thomas Smith & Sons (Rodley), Ltd.*)

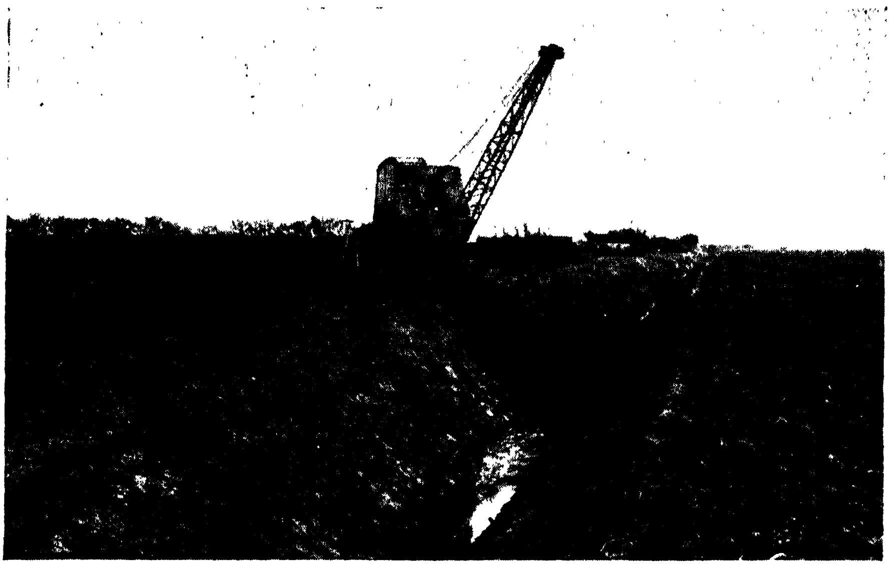

Fig. 11.—OPERATING WITH DRAGLINE EQUIPMENT. (*Ransomes & Rapier, Ltd.*)

them to be travelled about the job under their own power over practically any kind of ground with comparative speed and ease.

The tracks on excavator machinery are usually large enough to provide liberal bearing area on ordinary ground, and a good road can be negotiated without damaging its surface providing some discretion is used by the operator. When working on soft and boggy ground it is advisable to stand the machine on a timber base or sleepers.

If Excavator becomes Bogged

If the excavator should become bogged, no attempt should be made to travel. A good track must then be laid behind the machine so that the excavator can be travelled back on to a firm footing, and then a gentle incline can be laid in front of each track and the machine should climb out without any difficulty.

Travelling and Transport

Timber must also be put down when travelling over hard objects such as railway lines.

It may be necessary to obtain permission to travel on public roads, and the driver of the machine must hold a heavy driver's licence and have passed a test on this particular type of machinery.

When it is required to transport excavators from one job to another it is usually best to enlist the services of a transport company, most of whom have suitable lorries available for the purpose.

Adjustment

The carriage and caterpillar track will not work efficiently unless attention, as directed by the makers, is given to the adjustment of the parts, and excessive wear will soon take place unless the various shafts and wheels are lubricated daily.

Attention to Ropes

The wire ropes require careful attention, and frequent inspection should be made for signs of wear, abrasions, or breaking at the fixing. In the last case, take rope out of the socket and cut off faulty part of rope and refix in socket. Bind the rope with wire before cutting. The following points are important and should be carefully noted :

1. Avoid sudden tautening and whipping.
2. Avoid crossing or heaping-up on barrels.
3. Avoid kinks when uncoiling new rope.
4. New ropes that are being held in hand for spares should be stocked in a dry place. Do not expose to the weather, nor allow to lie in water or on a damp floor.

EXCAVATOR OPERATION

The following notes give an indication as to the best methods of operating excavator machinery using the different attachments. The Smith excavator is selected as an example.

Derricking Unit

This fitting, which is a worm gear enclosed in an oil case and fitted with automatic brake, is necessary for the dragline and grabbing crane, and recommended for the ordinary crane. It is used for raising and lowering the jib.

Digging Operations with the Shovel Attachment

The bucket is lowered to the ground ready for an upward cut, care to be taken that the bucket does not swing back and hit the carriage or jib. Too thick a cut should not be attempted ; instead, the bucket should thrust in the material to dig an even cut extending the full face, sufficient to fill the bucket. The thickness of the cut is regulated by the thrusting action obtained by raising or lowering the jib at the same time as digging. When the bucket is full, the machine is slewed round to the dump, and the contents discharged. No attempt must be made to slew while the bucket is in the face.

The bucket door is released for discharging by pulling on the hemp rope that connects up to the catch gear on the bucket. The bucket can be lowered while slewing back to cut and the operations repeated. On lowering the bucket the door automatically closes.

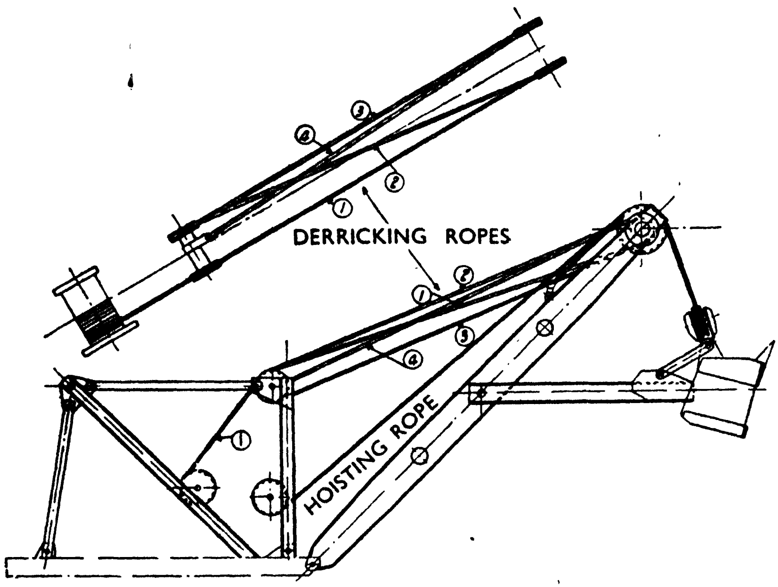

Fig. 12.—Arrangement of ropes for shovel attachments
(*Thomas Smith & Sons* (*Rodley*), *Ltd.*)

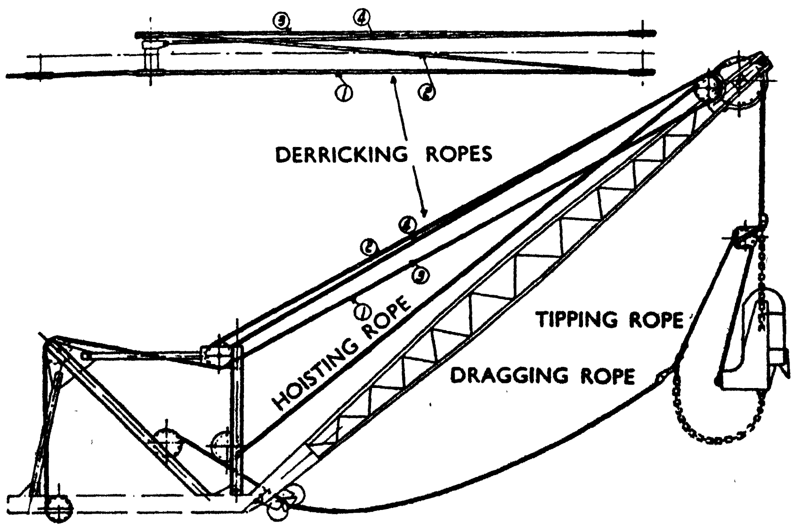

Fig. 13.—Arrangement of ropes for dragline attachment
(*Thomas Smith & Sons* (*Rodley*), *Ltd.*)

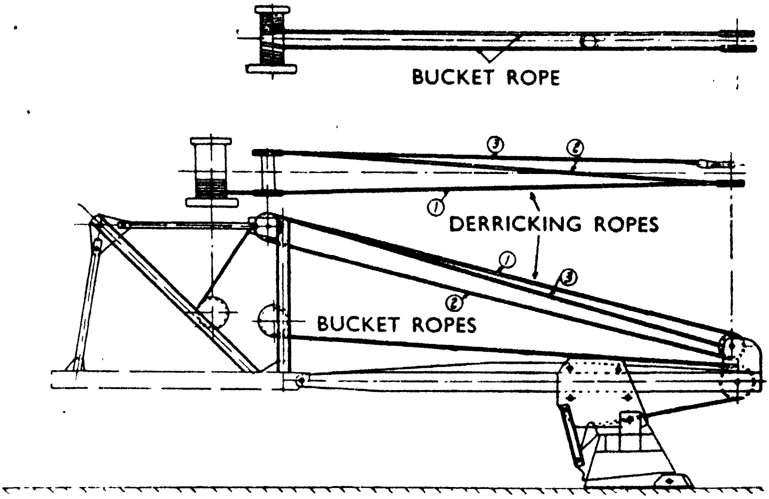

Fig. 14.—ARRANGEMENT OF ROPES FOR SKIMMER SCOOP ATTACHMENT
(*Thomas Smith & Sons* (*Rodley*), *Ltd.*)

The bucket-hoisting rope is secured to the front barrel and the derrick rope to the rear barrel as shown in Fig. 12.

Digging Operation with Dragline Attachment

The bucket is lowered from the jib head to the ground and pulled inwards to the machine. When the bucket is full, the drag brake is applied sufficiently to allow the drag rope to be paid out whilst hoisting the bucket in a horizontal position. When high enough, hoisting is ceased and both brakes put full on so as to hold the bucket. To empty the bucket when having reached the discharging point, release the drag brake.

The bucket should take a thin cut so that a complete travel of excavation fills the bucket.

The depth of cut can be regulated by the hoisting rope.

To throw the bucket beyond the jib head, pull the bucket well under the jib, and release the drag brake to allow the bucket to swing out. At the maximum point of swing, " brake " the drag rope and release the hoist rope ; as the bucket reaches the ground, " brake " the hoist rope immediately.

Ropes

The dragging rope is secured to the rear barrel and the hoisting rope to the front barrel. Care must be taken that these ropes do not slacken and overrun the barrels at the times when the hoisting rope is lowering the bucket, or drag rope is being paid out with a full bucket, and also when discharging. The derrick rope is secured to the derrick barrel.

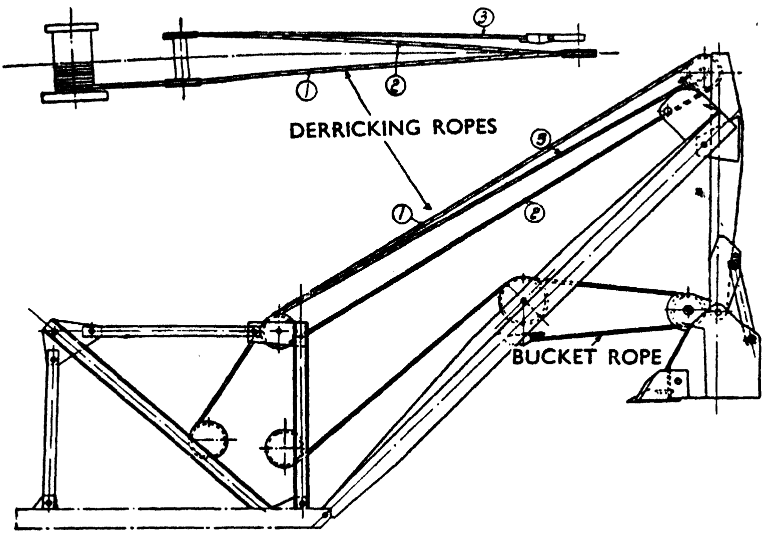

Fig. 15.—ARRANGEMENT OF ROPES FOR BACK-ACTING TRENCHER ATTACHMENT
(*Thomas Smith & Sons* (*Rodley*), *Ltd.*)

Digging with the Skimmer Scoop Attachment

The jib is placed parallel with the ground, the bucket being at the foot end of the jib. The bucket is hauled along, taking a cut sufficiently deep to fill itself by the time it has reached the jib head. The bucket rope brake is then applied and the jib lifted, the machine slewed round to the discharging point, and the bucket emptied by pulling on the hemp rope which connects with the catch gear on the bucket. The bucket is run down the jib while the machine is slewing back to the excavation, the door shutting itself when the bucket is pulled up. The bucket must be stopped by applying the brake, and not allowed to make violent impact with the buffers on the jib. Resting the bucket on the ground, the next cut can be taken.

Care must be taken not to lower the jib heavily on to the bucket.

N.B.—The jib is the same as used for the back-acting trencher attachment.

One rope is used for the bucket and both ends are secured to the front barrel. When changing over from one of the other attachments to the skimmer scoop, the outer barrel, which is in halves and bolted together, is removed, and the inner barrel used for the skimmer bucket rope.

The derrick rope is secured to the rear barrel. The bucket and derrick ropes are the same as used for the shovel and back-acting trencher attachments.

Working Operations with Back-acting Trencher Attachment

Commencing over the cut to be made, lower the jib, at the same time let the bucket out slowly. When the bucket is fully extended, lower until touching the material and commence to pull in. A uniform cut should be taken sufficient to fill the bucket in its maximum travel. When the bucket is full, it should be well under the jib; raise the jib until the bucket clears the ground. Slew round to the dump and discharge contents. By pulling on the hemp rope, the catch gear on the bucket is operated to open the door.

When it is required to discharge material from the bucket without using the door, a plate is bolted on each side of the bucket to secure the door. To discharge, the bucket is let out slowly over the dump and the material allowed to fall out. The jib is the same as used for the skimmer scoop attachment.

The bucket rope is the same as used for the shovel, and is secured to the front barrel, and the derrick rope to the rear barrel.

The derrick rope is the same as used for the shovel and skimmer scoop attachments.

Working Operations for the Grabbing Attachment

Lower the open grab to the excavation, pull on the closing rope, which causes the bucket to close and fill itself. Still using the closing rope, lift to the required height and apply the brake on both rope barrels. Slew round to dump and discharge material. To discharge, keep the brake on the holding-rope barrel and take off brake on closing-rope barrel. Then reverse slew and lower the bucket to repeat operations.

The holding rope is secured to the front barrel, and the closing rope to the rear barrel. The derrick rope is secured to the derrick barrel.

Note that in ordinary working it is not necessary to operate the front-barrel clutch ; this clutch must be so adjusted that it turns the barrel sufficient only to keep the holding rope taut.

The front-barrel clutch should only be used when it is required to lift the grab when open.

Crane Attachment

For the heavier loads, the double-rope pulley block must be used and the single rope is used for the lighter loads, according to the specified rating given with each machine. The hoisting rope is secured to the front barrel.

The derricking unit is recommended for this attachment, but when not fitted the jib may be derricked by using the rear barrel.

Do not snatch at the load when hoisting, and do not apply the brake suddenly.

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